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REPORT OF THE MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON THE

REPORT OF THE MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

NOVEMBER 2, 1989

Printed for the use of the
Committee on Energy and Natural Resources

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REPORT OF THE MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

NOVEMBER 2, 1989

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:40 a.m., in room SD-366, Hon. J. Bennett Johnston, chairman, presiding.

OPENING STATEMENT OF HON. J. BENNETT JOHNSTON, U.S. SENATOR FROM LOUISIANA

The CHAIRMAN. The hearing will come to order. Today we are holding a hearing to receive testimony from the Monitored Retrievable Storage Review Commission. Their report was released just yesterday.

This hearing is the first presentation by the Commissioners to a Congressional Committee. I welcome the Commissioners here today. They are Alex Radin, formerly head of the American Public Power Association, Dr. Dale E. Klein, Associate Dean for Research at the University of Texas in Austin, and Dr. Frank L. Parker, Professor of Environmental and Water Resources Engineering at Vanderbilt University.

The report of the Commission is important, because the Commissioners are to recommend whether a monitored retrievable storage facility for nuclear waste "should be included in the national nuclear waste management system."

The Department of Energy may not begin efforts to site a monitored retrievable storage facility until this report is submitted. The establishment of the Commission was an attempt to obtain a dispassionate look at the MRS concept, that is, the idea of storing nuclear waste in a way that maintains continuous control of the waste and permits continuous monitoring of its condition.

This idea can be seen as an alternative to the disposal of the waste in a deep underground repository, or it can be seen as an integral feature of the repository program. Opponents and supporters of the MRS idea have adopted both views.

It is very clearly and strongly my view that it is part of an integral feature of the repository program. The Commission is looking at the MRS as a part of the national nuclear waste management system, a system that includes a repository.

The system is supposed to begin receiving nuclear waste by January 31st, 1998. Given the present repository schedule, an MRS is probably the only hope of the Federal Government meeting this

pledge. Given the uncertainty in the date of repository operation, MRS is the only hope that ratepayers will receive some service for their money until well into the 21st Century.

The Commission report will speak for itself. Since the inception of our efforts in nuclear waste policy I have been a firm proponent of the Federal Government fulfilling its promises to manage the nuclear waste from civilian and defense nuclear activities.

I have seen the idea of monitored retrievable storage as an asset in carrying out this Federal responsibility in a safe and environmentally responsible fashion. This continues to be my view. Today we will hear what the Commission's view is.

Gentlemen, welcome to the Committee.

[The Executive Summary of the report follows:]

Nuclear Waste: Is There A Need For Federal Interim Storage?

EXECUTIVE SUMMARY ONLY

Report of the Monitored Retrievable Storage Review Commission

November 1, 1989

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Washington, D.C. 20402

MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

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Alex Radin
Chairman

Dale E. Klein
Commissioner

Frank L. Parker
Commissioner

Jane A. Axelrad
Executive Director and
General Counsel

November 1, 1989

The Honorable Thomas S. Foley
Speaker of the House
United States House of Representatives
H-204 Capitol
Washington, D.C. 20515-6501

The Honorable Robert C. Byrd
President Pro Tempore
United States Senate
Hart Office Building, Suite 311
Washington, D.C. 20510-1902

Dear Speaker Foley and Senator Byrd:

The Monitored Retrievable Storage Review Commission herewith submits its final report as required by the Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203, as amended by Public Law 100-507.

The Congress created the Commission to provide a report on the need for a Federal monitored retrievable storage facility (MRS) as part of the Nation's nuclear waste management system. In essence, Congress asked the Commission to review the U.S. Secretary of Energy's proposal to create an MRS, evaluate the technical need for an MRS, obtain data and comments from affected parties, and recommend whether such a facility should be included in the nuclear waste management system.

The Commission concludes that the MRS as presently described in the law, which links the capacity and schedule of operation of the MRS to a permanent geologic repository, cannot be justified. The Commission finds, however, that while no single factor would favor an MRS over the No-MRS option, cumulatively the advantages of an MRS would justify the building of an MRS if: (1) there were no linkages between the MRS and the repository; (2) the MRS could be constructed at an early date; and (3) the opening of the repository were delayed considerably beyond its presently scheduled date of operation.

The Commission notes that the Congress, for many years, has expressed concern that an unlinked MRS might be regarded as a de facto repository and could reduce the impetus for proceeding with permanent geologic disposal. The Commission recognizes this expression of Congressional will, as well as similar sentiments voiced during the course of its hearings. Although the Commission does not believe that there is a technical basis for the linkages, the Commission concludes that some linkages are justified.

Based on our studies, and the conclusions noted above, the Commission has decided that some limited interim storage facilities would be in the national interest to provide for emergencies and other contingencies. The Commission feels that such facilities would be especially desirable in light of delays which have already been experienced as well as additional delays that might be encountered in building a permanent geologic repository. The Commission therefore recommends that the Congress take the following actions:

1. Authorize construction of a Federal Emergency Storage (FES) facility with a capacity limit of 2,000 metric tons of uranium.

2. Authorize construction of a User-Funded Interim Storage (UFIS) facility with a capacity limit of 5,000 metric tons of uranium. Such a facility would provide only storage, and would be in addition to the FES.

3. Reconsider the subject of interim storage by the year 2000 to: (a) take into account uncertainties that exist today and that might be resolved or clarified within ten years; (b) consider developments that cannot be anticipated today; and (c) evaluate the experience with the two facilities recommended above.

The Commission believes that these recommendations, together with the analyses contained in the report, carry out the mandate given the Commission by the Congress.

We thank you for the opportunity to serve the Congress. It is our hope that the report will assist the Congress as it continues to deliberate on the management and disposal of the Nation's spent nuclear fuel. We stand ready to assist Congress in any way possible to accomplish this goal.

Sincerely,

Alex Radin

Alex Radin
Chairman

Dale E. Klein

Dale E. Klein
Commissioner

Frank L. Parker

Frank L. Parker
Commissioner

MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

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Commission Activities

After being sworn into office on June 14, 1988, the Monitored Retrievable Storage (MRS) Review Commission members assembled and organized a small staff. The Commission operated as a collegial body, with commissioners intimately involved in directing the research and establishing the report writing methodology. From June 14, 1988, until November 1, 1989, the Commission met formally almost every other week. In addition, commissioners traveled individually to gather pertinent information.

All Commission meetings with outside persons or organizations were open to the public. Transcripts of public meetings and routine correspondence were available for review in a Public Document Room at the Commission's offices in Washington, D.C.

The Commission solicited the views of a broad spectrum of people and organizations by holding public hearings in Washington, D.C.; Denver, Colorado; San Francisco, California; and Atlanta, Georgia. (See Appendix A.) The hearings were well attended and produced a wealth of information and insights used during the Commission's deliberations. A total of 173 private citizens, nuclear waste experts, nuclear utility officials, State and local government representatives, Members of Congress, and representatives of citizen and environmental action groups testified, expressing a wide variety of views and, in many instances, submitting statements for the record. Commissioners listened to and questioned each witness concerning the rationale and long-term consequences of his or her recommendations. The Commission also received statements for the record from people unable to attend the hearings. (See Appendix B.)

Throughout its study, the Commission conducted public briefings to gather relevant information. (See Appendix C.) In July 1988, the U.S. Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), Members of Congress and their staffs, the General Accounting Office (GAO), the nuclear industry, the State of Tennessee, and environmental action groups briefed the Commission on monitored retrievable storage work done before the Commission was created.

In September 1988, the Commission requested a series of briefings on specific topics by DOE and NRC representatives. DOE presented information on its ongoing studies on the need for an MRS facility, rod consolidation, its dry cask storage study, and the status of the repository program. NRC briefed the Commission on its procedures for licensing independent spent fuel storage installations and certifying casks for transportation of spent nuclear fuel.

Soon after its formation, the Commission determined it needed to examine first-hand how utilities and others handle and store spent fuel. In October 1988, the Commissioners and the Commission's Executive Director visited Carolina Power and Light Company's H.B. Robinson Nuclear Project in Hartsville, South Carolina, and Virginia Power Company's Surry Nuclear Power Station in Surry, Virginia. Although these are the only U.S. commercial nuclear power plants currently using at-reactor dry storage facilities for spent fuel, other utilities are exploring the possibility. The facilities' handling and storage of spent fuel were examined, and the utilities' reasons for adopting this type of storage and their plans for the future were discussed.

In addition to those site visits, the Commissioners and Executive Director visited facilities in Sweden, the Federal Republic of Germany, France, and Switzerland to learn about the European experience with spent fuel storage and to examine possible components of an interim storage system. They observed many approaches to spent fuel management ranging from wet centralized storage of spent fuel at CLAB in Sweden to the dry centralized storage of vitrified high-level wastes from reprocessing at La Hague in France. (See Appendix D.)

Following this trip, the Commission held a public briefing in Washington, D.C., in November 1988, to obtain additional information from officials of COGEMA, a French nuclear fuel cycle company. Another briefing followed in December 1988 to obtain information from DOE on its program to construct a permanent repository for the disposal of nuclear waste. Department officials briefed the Commission on efforts to characterize the Yucca Mountain site in Nevada and the schedule for providing a permanent repository for high-level radioactive waste.

In March 1989, DOE provided the Commission with the preliminary results of its system studies on the need for an MRS facility. In May 1989, DOE supplied the final results of those studies and stated the department's current

position on the need for an MRS facility. At the same meeting, NRC officials briefed the Commission on safeguards issues associated with a potential MRS facility.

The Commission's evaluation focused on a series of alternative waste management strategies. Acting on an early decision to contract for assistance to augment its staff efforts in performing needed complex analyses, initial contracts totaling $827,836 were awarded in February 1989 to perform five technical tasks and to provide data and analytical tools for the Commission to use in performing its evaluation. The same month, the Commission sent Congress and other interested parties a status report detailing Commission activities to date.

In March 1989, the Commission invited a group of experts to review a draft outline of the report. They represented a wide range of views pertaining to the nuclear waste issues the Commission was examining and provided their expert perspectives on the scope of the report.

Throughout the summer, the Commission received results of the contractors' work. Contractors' work, which included development of two computer models, augmented technical and public policy work already underway. (See Appendix E.) The Commission also received, in July 1989 the State of Tennessee's final study on the need for an MRS facility. In August, Edison Electric Institute submitted a study on the role of an MRS prepared by Energy Resources International at the request of the Edison Electric Institute/Utility Nuclear Waste and Transportation Program. The Commission held a retreat in August to determine its conclusions and recommendations.

This report, completed during the remaining months of the Commission's existence, reflects the Commission's extensive technical work and public policy deliberations.

Executive Summary

About 20,000 metric tons of spent, or used, nuclear fuel have accumulated since the beginning of commercial nuclear power production in the United States. At the end of the currently licensed period of all existing nuclear power plants and those under construction, the amount of spent nuclear fuel is expected to total 87,000 metric tons.

Thus far, practically all of the spent nuclear fuel is stored in water-filled pools at reactor sites. However, space does not exist in the pools to store all the spent fuel expected to accumulate over the lifetime of the reactors. Therefore, other storage must be made available.

U.S. policy is to dispose of spent fuel from nuclear power plants in a permanent underground geologic repository. The objective of permanent disposal is to limit to safe quantities the amount of nuclear waste that might reach the biosphere during the next 10,000 years and beyond.

To achieve that objective, Congress, in the Nuclear Waste Policy Amendments Act of 1987 (NWPAA), designated Yucca Mountain, Nevada, as the candidate site for a repository. Final selection of the Yucca Mountain site was made subject to extensive studies of the suitability of this site and other conditions.

The objective of Congress in adopting the NWPAA was to have a repository available for accepting spent fuel in 1998. However, the U.S. Department of Energy (DOE), which has responsibility for characterizing the Yucca Mountain site, has announced that the opening of the repository will be delayed until 2003, and it is likely that there will be additional delays.

To store spent fuel until the permanent repository is available, a monitored retrievable storage (MRS) facility has been proposed by DOE. The MRS would serve as a means of collecting spent fuel, in excess of that in reactor pools, in a central location, where it would be stored until the fuel can be accepted at the repository. It has also been proposed that the MRS could serve other purposes, such as consolidating the fuel and packaging it for ultimate disposal in the repository.

Facilities similar to an MRS have been proposed since 1972 and have always been the subject of considerable controversy. As recently as 1987, DOE proposed to build an MRS at the Clinch River site near Oak Ridge, Tennessee. In adopting the NWPAA later that year, however, Congress "annulled and revoked" the DOE proposal to locate an MRS in Tennessee.

In the same law, Congress authorized the construction of an MRS but created the Monitored Retrievable Storage Review Commission to study and report to Congress on whether an MRS should be a part of the Nation's nuclear waste disposal system. Essentially, Congress directed the MRS Review Commission to compare the options of a waste disposal system that included an MRS with one that did not include an MRS. The latter, which is known as the No-MRS alternative, would require continued storage of spent nuclear fuel at the more than 70 existing sites of nuclear power plants until the repository is operational.

In the NWPAA, DOE was directed to begin site surveys for an MRS only after the MRS Review Commission had submitted its report to Congress. The NWPAA also limited the capacity of the MRS and linked its construction and operation to the repository schedule.

This report represents the results of almost 18 months of study and deliberations by the MRS Review Commission in response to its mandate from Congress. In addition to its own studies and evaluations, the Commission contracted a number of studies by independent consultants; held extensive public hearings in four locations in the United States; reviewed detailed studies by DOE, the State of Tennessee, and others; received numerous written statements; and visited nuclear waste storage sites in the United States and in four European countries.

As a result of its extensive studies and deliberations, the Commission reached the following conclusions:

Conclusion No. 1. From a technical perspective, both the No-MRS and MRS options are safe.

Although neither option is completely without risk, the Commission determined that the risks are expected to be small and within regulatory limits, and the degree of difference in risks is so small that the magnitude of difference should not affect the decision as to whether there should be an MRS.

Conclusion No. 2. The net cost of a waste management system that includes an MRS would be lower than previously estimated because of delays that have already occurred in the expected date of repository operation, and the likelihood of further slippages of that date.

The economics of an MRS would become more favorable if the repository were delayed and if the MRS were to accept spent fuel as early as possible. These effects would become especially significant if the repository operation were to be delayed beyond 2013, when there will be a sharp increase in the number of nuclear power plants whose current licenses will expire. If a repository were not in operation by that time, utilities would incur major additional costs that would result from the inability to remove spent fuel from plants being decommissioned. However, a system with an MRS would still be somewhat more costly on a discounted basis than one without an MRS.

Conclusion No. 3. There are no single discriminating factors that would cause the MRS alternative to be chosen in preference to the No-MRS alternative.

Although the Commission does not find any single factor that would cause it to favor one alternative, it believes that, cumulatively, there are a number of advantages that would justify a central storage facility not limited in capacity nor linked to the repository schedule and operation. These advantages include storage for emergency purposes; storage for utilities which do not have sufficient space in their spent fuel pools or on-site or which cannot obtain a license for additional at-reactor storage and, hence, might be required to shut down an otherwise satisfactorily operating nuclear power plant; storage for spent fuel from shutdown reactors; economies in the waste management system if an MRS could be completed substantially before the repository; greater redundancy in the system in the event of unforeseen circumstances; more surge capacity to facilitate the flow of spent fuel to the repository; more flexibility in storage options and future waste preparation functions; assistance in standardization; and initiating Federal responsibility for taking possession of spent fuel.

Conclusion No. 4. An MRS linked as provided in current law would not be justified, especially in light of uncertainties in the completion time for the repository. Consequently, the Commission does not recommend a linked MRS as required by current law and as proposed by DOE.

The Commission notes that Members of Congress, other public officials, environmental groups, and many private citizens for many years have expressed concern that an unlinked MRS might be regarded as a de facto repository, and thereby would reduce the impetus for building the repository as expeditiously as possible. Although the Commission does not believe that there is a technical basis for the linkages, the Commission agrees that, in light of congressional and other concerns about a de facto repository, some linkages are justified.

However, the schedule linkage presently in the NWPAA (MRS construction may not begin until the Nuclear Regulatory Commission issues a license for the construction of a repository) would make it impossible for an MRS to be operational more than three years before the repository. Because of delays already experienced in the repository schedule and continued uncertainty surrounding the repository's location and date of operation, the value of the MRS would be greatly diminished if its construction were tied to the schedule of the repository. Most of the need for an MRS would have disappeared, in that utilities would have had to make other arrangements for storage.

Conclusion No. 5. Some interim storage facilities, substantially more limited in capacity and built under different conditions than the DOE-proposed MRS, are in the national interest to provide for emergencies and other contingencies.

The Commission recognizes the need to provide certain services that would be in the national interest, but which could not be provided by an MRS restricted by the schedule linkages currently in the law. The Commission concludes that spent fuel storage for emergency and other purposes would be in the national interest. Facilities to fulfill this national interest could be more limited in scope and could be built under different conditions than the DOE-proposed MRS.

In view of the conclusions noted above, and in light of its extensive studies and deliberations, the Commission recommends the following:

Recommendation No. 1. Congress should authorize construction of a Federal Emergency Storage (FES) facility with a capacity limit of 2,000 metric tons of uranium (MTU).

In light of the continuing delay in the building of a repository, the Commission believes it would be in the national interest to have available a safety net of storage capacity for emergency purposes, such as an accident at a nuclear power plant, which would make it advantageous to have the plant's spent fuel pool available for decontamination of affected parts of reactors and for storage of debris.

If the facility proposed in Recommendation No. 2 were not available, the FES also could be used to store spent fuel from otherwise satisfactorily operating nuclear power plants that would have to be shut down because of insufficient on-site storage.

Because the FES would be designed primarily for emergency use and, hence, would serve as "insurance" for the entire industry, the Commission recommends that the cost of this facility should be paid from the Nuclear Waste Fund, to which all of the utilities which generate power from nuclear energy contribute.

Recommendation No. 2. Congress should authorize construction of a User-Funded Interim Storage (UFIS) facility with a capacity limit of 5,000 MTU. Such a facility

would provide storage only, and would be used in addition to the Federal Emergency Storage facility proposed in Recommendation No. 1.

Although spent fuel can be stored safely at reactor sites for as long as 100 years, some utilities may not have space on-site for life-of-plant storage or may not be able to obtain a license for additional storage.

In view of the uncertainties regarding the availability of a repository, the Commission believes it would not be in the national interest to force utilities to shut down operation of otherwise satisfactorily operating nuclear power plants because of lack of storage capacity for spent fuel. Congress recognized this problem by authorizing, in Section 135 of the Nuclear Waste Policy Act of 1982, a Federal Interim Storage facility (FIS). It is the Commission's intention that the 5,000 metric ton storage facility that it recommends likewise should be available in such contingencies.

This facility also should provide storage for: (a) shutdown reactors at sites where a utility no longer operates nuclear power facilities, and (b) utilities which would prefer to ship spent fuel to this facility rather than retain it on-site.

In view of the uncertainties which have existed as to the time of operation of the MRS and the repository, many utilities with newer reactors have already taken steps to provide needed life-of-plant storage, while others have expressed a preference for providing such storage themselves rather than relying on an MRS. For these reasons, the Commission believes it would be more equitable for the storage facility (UFIS) to be user funded, so that only those utilities that chose to use the facility would pay for it.

Recommendation No. 3. Congress should reconsider the subject of interim storage by the year 2000 to: (a) take into account uncertainties that exist today and which might be resolved or clarified within 10 years, (b) consider developments which cannot be anticipated today, and (c) evaluate the experience with the two facilities recommended above.

Many uncertainties make it extremely difficult to plan for long-term interim storage of spent fuel. Although the opening of the repository is the most notable uncertainty, many other questions also must be resolved.

The Commission believes that the actions recommended above should be adequate to take care of the needs of interim storage at least until the year 2006. However, by the year 2000, Congress should reconsider the question of interim storage of spent fuel. At that time, Congress should take into account, among other things, such factors as: status of the repository; status of nuclear power plants; availability of at-reactor storage; utilization and adequacy of the 2,000 metric ton Federal Emergency Storage facility and the 5,000 metric ton User-Funded Interim Storage facility; status of technological developments in the storage of spent fuel; nuclear waste system optimization; and the fee schedule established for the UFIS.

• • •

The Monitored Retrievable Storage Review Commission believes that these recommendations would provide safe interim storage of spent nuclear fuel, would be consistent with the goals of the national nuclear waste management system, and would provide for flexibility and unforeseen contingencies.

The CHAIRMAN. I understand that we will hear from my colleagues before we hear from the Commission. Senator McClure?

STATEMENT OF HON. JAMES A. McCLURE, U.S. SENATOR FROM IDAHO

Senator MCCLURE. Thank you very much. I am very eager to hear from the Commission. I have a prepared statement which I would ask unanimous consent be placed in the record in full.

The CHAIRMAN. Without objection.

Senator MCCLURE. My concern, Mr. Chairman, has been, as yours, that indeed we need to have a waste repository which can serve us within the predictable and I would hope immediate future, or at least the near-term future, not something like, well, maybe we can do something if we start in 2010 or 2030.

We need to move more expeditiously than that, even though we have received a great deal of cooperation from NRC in allowing in situ storage.

With the Chairman of the Committee support I have shared for MRS for years, and if the Senate had had its way and had not been forced to compromise that issue with the House we would be further along than we are. The House was definitely and adamantly opposed to an MRS, and I suggest to you that there are a great many people who are opposed to MRS because they do not want nuclear waste storage.

They find a weak link in the nuclear industry and they will strike at that weak link because they hate the industry. They are going to try to kill the industry by killing the opportunity for any storage. Any alternative which is possible becomes unacceptable. It is only the impossible things that they will accept, because they do not want anything done, in my view.

I think we need nuclear waste storage. That is why some years ago I, with others, sponsored and past legislation and created funding to accomplish it. I will look forward to your testimony, but I have not believed that the House position was correct, that this Committee's position in the past was the correct position, and when we establish linkage between permanent repository and the MRS I think we compounded the error.

I will be very interested and look very closely at the statements that are made as to why MRS cannot or should not be done, and with that, Mr. Chairman, I look forward to hearing from the witnesses.

[The prepared statement of Senator McClure follows:]

OPENING STATEMENT
SENATOR JAMES A. McCLURE (R-ID)
COMMITTEE ON ENERGY AND NATURAL RESOURCES
THURSDAY, NOVEMBER 2, 1989 (9:30 A.M.)

MRS COMMISSION REPORT

Good morning. Today the Committee turns its attention once again to the issue of monitored retrievable storage of spent nuclear fuel and high-level nuclear waste. Nuclear power is an integral component of our nation's long-term energy supply, and the operation of a system to safely and permanently dispose of high-level radioactive waste and spent nuclear fuel is critical to its future.

The Nuclear Waste Policy Act of 1982 (NWPA) initiated a comprehensive DOE program for the development of a system of nuclear waste repositories. The 1987 NWPA Amendments, as contained in the Omnibus Reconciliation Act of 1987, redirected and streamlined the program. However, while it authorized construction and operation of an MRS facility, it also linked its construction to the selection of a site for development as a permanent waste repository. One cannot proceed without the other.

Since 1972, those of us concerned for public health and safety have proposed MRS type facilities. As recently as 1987, DOE proposed an MRS at the Clinch River site near Oak Ridge. Meanwhile the quantity of spent nuclear fuel and high-level nuclear wastes continues to grow.

Today, just as two years ago, I believe that this linkage was a mistake. Construction of an MRS facility should not be conditioned on selection of a permanent repository site. Because MRS construction cannot proceed until site characterization at Yucca Mountain is completed, an MRS site may not be formally selected until the late 1990's. While the 1987 Amendments called for a permanent repository by 1998, DOE has announced that the opening will be delayed until at least the year 2003.

Spent nuclear fuel meanwhile continues to pile up at over 70 civilian reactors, awaiting either an MRS or a permanent repository. By the time a repository is fully operational, it is expected that the amount of spent nuclear fuel will have grown from the present 20,000 metric tons to over 87,000 metric tons -- well beyond the capacity of current on-site storage pools.

The problem is so acute that the MRS Commission has proposed an immediate authorization and construction of both a Federal Emergency Storage (FES) facility with a capacity of 2,000 metric tons of uranium and a User-Funded Interim Storage facility with a capacity of 5,000 metric tons. The recommendation has been forced on the MRS Commission by the uncertainties which exist as to when an MRS and the permanent repository will be operational.

This uncertainty arises from the linkage I mentioned. But, rather than recommend removal of the statutory linkage between the MRS and a

permanent geologic repository and permit the MRS to proceed, the Commission has recommended that a Federal emergency storage system and a private interim storage facilities be constructed, in lieu of an MRS facility. The Commission then goes on to recommend that the Congress revisit this issue in 10 years.

The MRS Commission's conclusion is that because of current delays, the value of an MRS will be greatly diminished as utilities are forced to find alternatives. I therefore must ask, why not simply remove the current linkage and permit the already authorized MRS to proceed?

If we were to fully adopt this policy for high-level wastes, the Federal government might well be forced to find sites for the interim storage of high-level nuclear wastes; just as DOE is now being forced to find interim sites for Rocky Flats' defense wastes because of the failure of WIPP to open on schedule. At some point this process must end and we must find a permanent solution for the permanent and safe disposal of nuclear wastes. The 1987 NWPA Amendments were intended to achieve that objective.

The American people have a right to expect that national policies governing the disposal of civilian and non-civilian nuclear waste will adequately protect the health and safety of the American people. The MRS Commission concluded that both the No-MRS and MRS options are safe. Although neither option is without risk, the risks to public health and safety are expected to be small and within regulatory limits, and the degree of

difference in risks between the No-MRS and MRS options is so small that the magnitude of difference should not affect the decision as to whether or not there should be an MRS.

Only when and if the American people understand that our nation's nuclear waste effort is formulated and being implemented with a dedication to the principles of confidence and competence, and a commitment to these principles, can it be effective. The American people have a right to expect nothing less. But we must move this program forward now.

Further delays are not in the national interest. For years we have known what needs to be done to characterize a potential site such as Yucca Mountain. On the basis of the information obtained from site characterization activities, we have the expertise to determine if a site is suitable. We now have the capability to design, construct and operate a facility that protects public health, safety and the environment. The remaining issues are not technical; they are political. Those individuals who delay a final solution to this problem are endangering the public health and safety of the very consumers that they claim to champion.

From this perspective, I look forward to hearing today's testimony.

The CHAIRMAN. Thank you, Senator McClure.
Senator Ford?

STATEMENT OF HON. WENDELL H. FORD, U.S. SENATOR FROM KENTUCKY

Senator FORD. Thank you, Mr. Chairman. I read last night the report of the Commission and find it hard to keep up with. We are in one position one time and another position another time, and then when you make all these reasoned judgments then you come down on what you ought to do.

So maybe we can put it all together today and I can follow you a little bit better than I did from the report. Mr. Chairman, with that, I look forward to the testimony of the Commission.

The CHAIRMAN. Thank you, Senator Ford.

Mr. Radin, welcome to the Committee and we are glad to hear from you.

STATEMENT OF ALEX RADIN, CHAIRMAN, MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION, ACCOMPANIED BY DR. DALE E. KLEIN, COMMISSIONER; DR. FRANK L. PARKER, COMMISSIONER; AND DR. ALLAN PULSIPHER, CHIEF ECONOMIST

Mr. RADIN. Thank you very much, Senator Johnston and members of the Committee. We have a prepared statement which I would like to ask be inserted in the record in full and I will read only portions of it, concentrating primarily on our conclusions and recommendations.

My name is Alex Radin. I am serving as Chairman of the MRS Review Commission, and on behalf of myself and other members of the Commission I want to express our appreciation for the opportunity to appear before you today to present the results of this Commission's evaluation of the need for a monitored retrievable storage facility as part of the Nation's nuclear waste management system.

With me today are my fellow Commissioners, Dr. Dale Klein and Dr. Frank Parker. Although I am presenting this opening statement on behalf of the Commission, I want to emphasize that the Commission operated in a collegial manner and unanimously supports the report's conclusions and recommendations.

The Commission submitted its report to Congress yesterday in accordance with its charge in the Nuclear Waste Policy Amendments Act of 1987. That statute directed the Commission to first review the status and adequacy of the Department of Energy's proposal to bring an MRS into the national nuclear waste disposal system. Second, to obtain comment and available data on monitored retrievable storage from affected parties, including states containing potentially acceptable sites. Third, to evaluate the utility of a monitored retrievable storage facility from a technical perspective, and fourth to make a recommendation to Congress on whether a monitored retrievable storage facility should be included in the nuclear waste management system.

The report represents the results of almost 18 months of study and deliberation by the Commission in response to its mandate from Congress. The Commission solicited the views of a broad spectrum of people and organizations by holding public hearings in

four cities in the United States. The hearings were well attended and produced a wealth of information and insights that were used during our deliberations.

Soon after its formation, the Commission determined it needed to examine first-hand how utilities and others handle and store spent fuel. In October 1988 the Commissioners and the Commission's executive director visited Carolina Power & Light Company's H. B. Robinson Nuclear Project in Hartsville, South Carolina and Virginia Power Company's Surry Nuclear Power Station in Surry, Virginia.

Although these are the only U.S. commercial plants currently using at-reactor dry storage facilities for spent fuel, other utilities are exploring the possibility. The facilities' handling and storage of spent fuel were examined, and the utilities' reasons for adopting this type of storage and their plans for the future were discussed.

In addition to those site visits the Commissioners and the Commission's executive director visited facilities in Sweden, the Federal Republic of Germany, France and Switzerland to learn about the European experience with spent fuel storage and to examine possible components of an interim storage system.

We observed many approaches to spent fuel management, ranging from wet centralized storage of spent fuel in Sweden to the dry centralized storage of vitrified high-level waste from reprocessing in France.

We also hired a contractor to prepare a more detailed report on the waste management practices of the countries we visited and to report to us on four other countries, Canada, Japan, Spain and the United Kingdom. The contractor's work is printed in full in Appendix D of our report.

Through our examination of spent fuel management practices in other countries, we concluded that the experience of these countries provides useful insights but does not provide any single, clear message for U.S. spent fuel storage policy, and that's because of differences in the geography of the countries, their political and other institutional differences and various other factors which are described in the report.

Throughout the course of its study, the Commission received briefings by the Department of Energy, the Nuclear Regulatory Commission, the General Accounting Office, other government agencies and private entities. These briefings were open to the public, and transcripts of the briefings were kept.

The support we received from these agencies and particularly the Department of Energy and the Nuclear Regulatory Commission was exceptional, and we would like to express our appreciation for their efforts.

The State of Tennessee was also actively involved in MRS issues during our study. Representatives of the state participated in our public hearings and in July 1989 the state submitted to us the results of its most recent studies on the need for an MRS facility.

As I am sure you recognize, Mr. Chairman and Committee members, the issues assigned to us for study encompass complex, contentious questions. Solutions to these problems are not susceptible to simple, unequivocal answers. Although there are many technical

aspects to the questions, the responses require the application of judgment and policy considerations.

The commission's recommendations are intended to be consistent with the primary goal of the nation's nuclear high-level radioactive waste disposal program to construct and operate a geological repository as expeditiously as possible, consistent with meeting necessary safety and other public interest considerations.

The commission has evaluated an MRS and other alternatives using at reactor storage or the no-MRS case as the basis for comparison. The commission evaluated an MRS on the basis of whether its advantages would exceed its disadvantages. Although studies by DOE and others have shown that an MRS is more expensive than a no-MRS case, the commission does not believe that economics alone should be the deciding factor in determining whether there should be an MRS.

The commission's task has been made more difficult by the many uncertainties that confront the national waste management program, especially the date when the repository will be in operation. Although site characterization activities are now focused on Yucca Mountain, no site has been finally selected yet, and it is not know when a site will be designated and licensed. Delays have already occurred in the anticipated date for repository operation, and it is expected further schedule slippages will occur.

Thus, one of the most important factors driving the commission's recommendations has been an attempt to mitigate any adverse effects on the nation's nuclear waste management program that might result from uncertainty with respect to the repository's date of operation.

Mr. Chairman and members of the committee, in order to save time, I would like to skip now to page 9 of my prepared testimony and go directly into the conclusions and recommendations we made. Before I do that, though, and mention has already been made of the linkages that are in the law, and they were an extremely important part of our final decision making, I think it might be well to review just what those linkages are. They are shown in Figure 1.3 at the end of my prepared statement, and let me put in the record what those linkages are.

First, they state that the construction of an MRS may not begin until the NRC has issued a license for the construction of a repository.

Second, they say that the construction of this facility, the MRS, or acceptance of spent nuclear fuel or high-level radio active waste shall be prohibited during such time as the repository license is revoked by the commission or construction of the repository ceases.

A third linkage is that the quantity of spent nuclear fuel or high-level radio active waste at the site of this facility, the MRS, at any one time may not exceed 10,000 metric tons of heavy metal until a repository accepts spent nuclear fuel or solidified high-level radioactive waste.

And finally, there's an overall ceiling of 15,000 metric tons on the capacity of the MRS. Those are extremely important conditions and, as I said, they figured importantly in our conclusions and recommendations.

We had five general conclusions after reviewing a mass of information and doing many studies, and those conclusions are, first, that from a technical perspective, both the no-MRS and MRS options are safe, although neither option is completely without risk.

The commission determined that the risks are expected to be small and within regulatory limits and the degree of difference is so small that the magnitude of difference should not affect the decision as to whether there should be an MRS. There are some tables appended to my statement, Tables 4.3, 5.1 and 5.3, that indicate the magnitude of those risks, which I think are quite small, particularly in comparison to risks from other sources of radiation, natural and otherwise.

Our second conclusion is that the net cost of a waste management system that includes an MRS would be lower than previously estimated because of delays that have already occurred in the expected date of repository operation and the likelihood of further slippages of that date.

We found that the economics of an MRS would become more favorable if the repository were delayed and if the MRS were to accept spent fuel as early as possible. These effects would become especially significant if the repository operation were to be delayed beyond the year 2013 when there will be a sharp increase in the number of nuclear power plants whose current licenses will expire. Attached to my statement is Figure 4.3, from our report, which shows how that buildup will occur in the retirements of nuclear power plants.

If a repository were not in operation by that time—that is, the year 2013—utilities would incur major additional costs that would result from their inability to remove spent fuel from plants being decommissioned.

I might interject here that we have found that the cost would be about $2-$3 million per year per site for every plant that was ready to be decommissioned but for which there was no place to remove the spent fuel.

However, as I have indicated, a system with an MRS would still be somewhat more costly on a discounted basis than one without an MRS.

Our third conclusion is that there are no single discriminating factors that would cause the MRS alternative to be chosen in preference to the no-MRS alternative. Although the commission does not find any single factor that would cause it to favor the MRS over the no-MRS alternative, it believes that cumulatively there are a number of advantages to justify a central storage facility not limited in capacity nor linked to the repository schedule of operation.

We looked at a number of different factors to see whether any one of them would justify an MRS, and we found that there was no single factor that would lead us to that conclusion. But, if you looked at a number of different factors, it would justify an MRS if it were not limited in capacity and not linked to the repository schedule as is required to be the case under present law.

Some of the factors we examined were to provide storage for emergency purposes; storage for utilities which do not have sufficient space in their spent fuel pools or on site or which cannot

obtain a license for additional reactor storage and, therefore, might be required to shut down an otherwise satisfactorily operating nuclear power plant because of storage; lack of storage for spent fuel from shutdown reactors; economies in the waste management system if an MRS could be completed substantially before the repository; greater redundancy in the system in the event of unforeseen circumstances, more surge capacity to facilitate the flow of spent fuel to the repository; more flexibility in storage options and future waste preparation functions; assistance in standardization; and initiating federal responsibility for taking possession of spent fuel.

All those advantages, I want to emphasize again, were if the MRS were not limited in capacity and not linked to the repository schedule.

Our fourth conclusion was that an MRS linked as provided in current law would not be justified, especially in light of uncertainties in the completion time for the repository. Consequently, the commission does not recommend a linked MRS as required by current law and as proposed by DOE.

The commission notes that members of Congress, other public officials, environmental groups and many private citizens for many years have expressed concern that an unlinked MRS might be regarded as a de facto repository and, therefore, would reduce the impetus for building the repository as expeditiously as possible.

Although the commission does not believe that there is a technical basis for the linkages, the commission agrees that in light of congressional and other concerns about a de facto repository, some linkages are justified. However, the schedule linkage presently in the Nuclear Waste Policy Amendments Act—and I refer particularly to the linkage that says that the MRS construction may not begin until the NRC issues a license for the construction of a repository—that linkage would make it impossible for an MRS to be operational more than three years before the repository.

Because of delays already experienced in the repository schedule and continued uncertainties surrounding the repository's location and date of operation, the value of the MRS would be greatly diminished if its construction were tied to the schedule of the repository. Most of the need for an MRS would have disappeared in that utilities would have had to make other arrangements for storage.

Our final conclusion was that some interim storage facilities, substantially more limited in capacity and built under different conditions than the DOE-proposed MRS, are in the national interest to provide for emergencies and other contingencies.

The commission recognizes the need to provide certain services that would be in the national interest, but which could not be provided by an MRS restricted by the schedule linkages currently in the law. The commission concludes that spent fuel storage for emergency and other purposes would be in the national interest. Facilities to fulfill this national interest could be more limited in scope and could be built under different conditions than the DOE-proposed MRS.

In view of these conclusions and in light of its extensive studies and deliberations, the commission recommends the following:

First, that Congress should authorize construction of a federal emergency storage, or what we call an FES facility, with a capacity limit of 2,000 metric tons of uranium.

In light of the continuing delay in building a repository, the commission believes it would be in the national interest to have available a safety net of storage capacity for emergency purposes, such as an accident at a nuclear power plant, which would make it advantageous to have the plant's spent fuel pool available for decontamination of affected parts of reactors and for storage of debris.

If the facility proposed in our second recommendation, which I will describe in a minute, were not available, the FES also could be used to store spent fuel from otherwise satisfactorily operating nuclear power plants that would have to be shut down because of insufficient on-site storage.

Because the FES would be designed primarily for emergency use and therefore would serve as insurance for the entire industry, the Commission recommends that the cost of this facility should be paid from the Nuclear Waste Fund, to which all of the utilities which generate power from nuclear energy contribute.

Our second recommendation is that Congress should authorize construction of a user-funded interim storage facility with a capacity limit of 5,000 metric tons of uranium. Such a facility would provide storage only and would be used in addition to the federal emergency storage facility proposed in our first recommendation.

Although spent fuel can be stored safely at reactor sites for as long as 100 years, some utilities may not have space on site for life-of-plant storage or may not be able to obtain a license for additional storage.

In view of the uncertainties regarding the availability of a repository, the Commission believes it would not be in the national interest to force utilities to shut down operation of otherwise satisfactorily operating nuclear power plants because of lack of storage capacity for spent fuel.

Congress recognized this problem by authorizing in section 135 of the Nuclear Waste Policy Act of 1982 a federal interim storage facility. It is the Commission's intention that the 5,000 metric ton storage facility that it recommends likewise should be available in such contingencies.

The second facility which we are recommending also should provide storage for shutdown reactors at sites where a utility no longer operates nuclear power facilities and for utilities which would prefer to ship spent fuel to this facility, rather than retain it on site.

In view of the uncertainties which have existed as to the time of operation of the MRS and the repository, many utilities with newer reactors have already taken steps to provide needed life-of-plant storage, while others have expressed a preference for providing such storage themselves, rather than relying on an MRS.

For these reasons, the Commission believes it would be more equitable for the storage facility to be user-funded so that only those utilities that chose to use the facility would pay for it.

Our final recommendation is that Congress should reconsider the subject of interim storage by the year 2000 in order to take into account uncertainties that exist today and which might be resolved or clarified within 10 years, to consider developments which cannot be anticipated today, and lastly, to evaluate the experience with the two facilities that we have already recommended.

Many uncertainties make it extremely difficult to plan for long-term interim storage of spent fuel. Although the opening of the repository is the most notable uncertainty, many other questions also must be resolved.

The Commission believes that the actions we have recommended should be adequate to take care of the need for interim storage at least until the year 2006. However, by the year 2000 Congress, we believe, should reconsider the question of interim storage of spent fuel.

At that time, Congress should take into account, among other things, such factors as the status of the repository, the status of nuclear power plants, the availability of at-reactor storage, the utilization and adequacy of the two facilities we have recommended, the status of technological developments in the storage of spent fuel, nuclear waste system optimization, and the fee schedule that is established for the second facility we recommended.

The Monitored Retrievable Storage Review Commission believes that these recommendations, together with analyses contained in other sections of this report, carry out the Commission's mandate from Congress. If implemented, the recommendations would provide safe interim storage of spent nuclear fuel, would be consistent with the goals of the National Nuclear Waste Management System, and would provide for flexibility and unforeseen contingencies.

The Commission urges Congress, whatever its decision, to act as promptly as possible with regard to interim spent fuel storage so that DOE, utilities and other affected parties can plan accordingly.

Dr. Klein, Dr. Parker and I want to express our appreciation to the Congress for giving us this opportunity to serve you. We hope that our report will be of assistance to you in resolving a difficult, contentious and important national issue.

Dr. Klein, Dr. Parker and I will be glad now to respond to your questions.

Thank you very much.

[The prepared statement of Mr. Radin follows:]

STATEMENT OF ALEX RADIN

CHAIRMAN

ON BEHALF OF MEMBERS OF THE

MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

before the

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

NOVEMBER 2, 1989

Mr. Chairman and Members of the Committee:

I appreciate the opportunity to appear before you today to present the results of the Monitored Retrievable Storage Review Commission's evaluation of the need for a monitored retrievable storage facility as part of the Nation's nuclear waste management system. With me today are my fellow Commissioners, Dr. Dale Klein and Dr. Frank Parker. Although I am presenting this opening statement on behalf of the Commission, I want to emphasize that the Commission operated in a collegial manner, and unanimously supports the report's conclusions and recommendations.

The Commission submitted its report to Congress yesterday, November 1, 1989, in accordance with its charge in the Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203, as amended by Public Law 100-507. That statute directed the Commission to: 1) review the status and adequacy of the Department of Energy's proposal to bring an MRS into the national nuclear waste disposal system; 2) obtain comment and available data on monitored retrievable storage from affected parties, including States containing potentially acceptable sites; 3) evaluate the utility of a monitored

retrievable storage facility from a technical perspective; and 4) make a recommendation to Congress on whether a monitored retrievable storage facility should be included in the nuclear waste management system.

The report represents the results of almost 18 months of study and deliberation by the Commission in response to its mandate from Congress. The Commission solicited the views of a broad spectrum of people and organizations by holding public hearings in Washington, D.C.; Denver, Colorado; San Francisco, California; and Atlanta, Georgia. The hearings were well attended and produced a wealth of information and insights used during our deliberations. A total of 173 private citizens, nuclear waste experts, nuclear utility officials, State and local government representatives, Members of Congress, and representatives of citizen and environmental action groups testified, expressing a wide variety of views and, in many instances, submitting statements for the record. The Commission listened to and questioned each witness concerning the rationale and long-term consequences of his or her recommendations. We also received statements for the record from people unable to attend the hearings.

Soon after its formation, the Commission determined it needed to examine first-hand how utilities and others handle and store spent fuel. In October 1988, the Commissioners and the Commission's Executive Director visited Carolina Power and Light Company's H.B. Robinson Nuclear Project in Hartsville, South Carolina, and Virginia Power Company's Surry Nuclear Power Station in Surry, Virginia. Although these are the only U.S. commercial plants currently using at-reactor dry storage facilities for spent fuel, other utilities are exploring the possibility. The facilities' handling and storage of spent fuel were examined, and the utilities' reasons for adopting this type

of storage and their plans for the future were discussed.

In addition to those site visits, the Commissioners and the Commission's Executive Director visited facilities in Sweden, the Federal Republic of Germany, France, and Switzerland to learn about the European experience with spent fuel storage and to examine possible components of an interim storage system. We observed many approaches to spent fuel management ranging from wet centralized storage of spent fuel at CLAB in Sweden to the dry centralized storage of vitrified high-level wastes from reprocessing at La Hague in France. We also hired a contractor to prepare a more detailed report on the waste management practices of the countries we visited and to report to us on four other countries: Canada, Japan, Spain, and the United Kingdom. The contractor's work is printed in full in Appendix D of our report.

Through our examination of spent fuel management practices in other countries, we concluded that the experience of these countries provides useful insights, but does not provide any single clear message for U.S. spent fuel storage policy. The U.S. must make its decisions in a situation that is very different in a number of important aspects: in the absolute size (much larger) and relative importance (generally smaller) of its nuclear power program; in the regulatory, institutional, and political environment for nuclear power and waste management; in the pressures to develop a permanent repository and the related concerns that central storage facilities would delay that goal; and in the geographic characteristics (e.g., transportation distances, population densities, and the range of options available for siting storage and disposal facilities) that must be taken into account in waste management policy.

Throughout the course of its study, the Commission received briefings by the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), the

General Accounting Office, other government agencies and private entities. These briefings were open to the public and transcripts of the briefings were kept.

I might note that the support we received from these agencies, and particularly the Department of Energy and the Nuclear Regulatory Commission, was exceptional and we would like to express our appreciation for their efforts.

In response to our charge to review the status and adequacy of the Secretary's evaluation of the systems advantages and disadvantages of bringing an MRS facility into the national nuclear waste management system, the Commission sought information from DOE on its ongoing work on monitored retrievable storage and related topics. DOE presented information on its ongoing engineering studies on the need for an MRS facility, rod consolidation, its dry cask storage study, and the status of the repository program. Department officials briefed the Commission on efforts to characterize the Yucca Mountain site in Nevada and the schedule for providing a permanent repository for high-level radioactive waste.

In March 1989, DOE provided the Commission with the preliminary results of its system studies on the need for an MRS facility. In May 1989, DOE supplied the final results of those studies and stated the department's current position on the need for an MRS facility.

The State of Tennessee was also actively involved in MRS issues during our study. Representatives of the State participated in our public hearings and in July, 1989, the State submitted to us the results of its most recent studies on the need for an MRS facility.

As I am sure you recognize Mr. Chairman and Committee members, the issues

assigned to us for study encompass complex contentious questions. Solutions to these problems are not susceptible to simple, unequivocal answers. Although there are many technical aspects to the questions, the responses require the application of judgment and policy considerations.

The Commission has attempted to address its mandate as objectively as possible and has considered the issues submitted to it in a broad perspective. The Commission's recommendations are intended to be consistent with the primary goal of the Nation's nuclear high-level radioactive waste disposal program: to construct and operate a geological repository as expeditiously as possible, consistent with meeting necessary safety and other public interest considerations.

The Commission has evaluated an MRS and other alternatives using at-reactor storage (No-MRS) as the basis for comparison. In doing its analyses, the Commission directed staff studies and was assisted by contractors. The Commission evaluated an MRS on the basis of whether its advantages would exceed its disadvantages. Although studies by DOE and others have shown that an MRS is more expensive than a No-MRS case, the Commission does not believe that economics alone should be the deciding factor in determining whether there should be an MRS.

The Commission's task has been made more difficult by the many uncertainties that confront the national waste management program, especially the date when the repository will be in operation.

Although site characterization activities are now focused on Yucca Mountain, no site has been selected yet, and it is not known when a site will be designated and licensed. Delays have already occurred in the anticipated date for repository operation, and it is expected that further schedule

slippage will occur. Thus, one of the most important factors driving the Commission's recommendations has been an attempt to mitigate any adverse effects on the Nation's nuclear waste management disposal program that might result from uncertainty with respect to the repository's date of operation.

From the information gathered during its deliberations, the Commission identified five key questions it sought to answer in its report.

1. Are the effects on health, safety, and the environment significantly different if some spent fuel is stored at an MRS facility instead of all being stored at reactors?
2. Are the transportation risks associated with using different routes and different modes of transport significantly different if spent fuel is stored at an MRS facility instead of at reactors?
3. What are the economic costs and benefits associated with storing spent fuel at an MRS facility as compared to at-reactor storage, and does a comparison of the costs and benefits make one option more desirable than another?
4. Are there economic and social equity issues that should be taken into consideration in determining the need for an MRS facility? If so, what are the equity issues and do they favor choosing an MRS facility over at-reactor storage?
5. Which policy issues should be taken into consideration in evaluating the need for an MRS facility, and do they make a significant difference in the evaluation?

These questions are answered in Chapters Four through Eight of the report and I will summarize the major findings on Questions One through Four. Question Five is answered in our conclusions and recommendations which will

follow the summary of our principal findings.

Our findings in response to Questions One through Four are:

- Health, safety, and environmental effects are expected to be small and within appropriate regulatory limits whether spent fuel is stored at an MRS facility or at reactor sites. (See attached Table 4.3.)
- Radiological and non-radiological risks arising from transporting spent fuel, regardless of transport mode or method, are expected to be small and within regulatory limits, whether fuel is transported to and from an MRS facility or directly from reactors to a repository. (See attached Tables 5.1 and 5.3.)
- If the repository were to begin operation in the year 2003 according to current U.S. Department of Energy (DOE) schedules, adding an MRS facility in the year 2000 would increase the undiscounted costs of the spent fuel management and disposal system by $2.2 billion. If the repository were to be delayed to the year 2013, the undiscounted costs of a system without an MRS facility would be slightly lower ($0.1 billion) than those of a system that included an MRS that was available in the year 2000. If the opening of the repository were to be delayed until the year 2023, a system that included an MRS facility that was available in the year 2000 would be less expensive (by $0.8 billion) in undiscounted costs than one that did not. If the costs were discounted and expressed as present values, assuming a four percent rate of discount, the No-MRS case would remain less expensive (by $0.5 billion) than the MRS case even if the repository were delayed to 2023. (See attached Table 6.8(a).)
- The principal reason the economics of an MRS would become more favorable if the opening of the repository were delayed beyond the year 2013 is

that after that time there will be a sharp increase in the number of nuclear power plants whose current licenses will expire. If neither an MRS nor a repository were available, total costs of a No-MRS case would increase substantially because of the costs of delaying the removal of spent fuel from shutdown reactors.

- The cost-related conclusions just summarized apply only to comparisons between a system without an MRS and a system with an unlinked MRS. A waste management system with an MRS subject to the current statutory linkages would be more expensive than a No-MRS system in all cases.
- Distributional consequences and equity issues would need to be addressed if an MRS facility were built, but are not discriminating factors in deciding between an MRS facility and at-reactor storage. The impacts of increased industrial activity can be assessed and compensated for in the traditional ways. The stigma effects, the perceived and potential impacts, are more difficult to quantify and to ameliorate.
- If a non-integral storage-only MRS were built with a limited capacity, it would be more equitable to ratepayers if it were user funded rather than financed from the Nuclear Waste Fund. Utilities would be encouraged to make more economically efficient choices among spent fuel storage alternatives. The case for user financing is stronger the more limited the MRS's capacity and the range of services it performs since the benefits are less widespread.

Recent studies by the State of Tennessee and DOE reached similar conclusions about health, safety, and environmental effects--that is, the differences between the No-MRS and MRS alternatives would be small. Although the studies agreed that the transportation impacts would be small in any case,

the Tennessee studies asserted that Tennessee's integrated No-MRS option would have the lowest impacts. The DOE and Tennessee studies concluded that a system with an MRS would be more costly than a system without an MRS, although none of the studies included the costs of delaying the removal of spent fuel from shutdown reactors. They did not agree on the amount of the cost increase with an MRS in the system, and they differed significantly on the nature and extent of the benefits to be realized by building an MRS facility. The Tennessee study assumed availability of a dual-purpose cask not licensed at this time in the United States.

This Commission was directed by Congress to compare the alternative of at-reactor storage of spent fuel to storage at an MRS facility, taking into consideration certain factors. Several of these factors were addressed in the previous findings. However, three of the factors could not be specifically addressed by the Commission: the impact on "repository design and construction; waste package design, fabrication and standardization; and waste preparation." (Sections 143(a)(2)(A-C) of the Nuclear Waste Policy Act, as amended). Because no repository site has yet been chosen or licensed, it was not possible to make findings on any of these three items since their consideration depends upon the host rock of the repository. However, the Commission's recommendations are structured so that they will foster such consideration and will not negatively impact on repository design and construction; waste package design, fabrication, and standardization; and waste preparation.

As a result of its extensive studies and deliberations, the Commission reached five conclusions:

Conclusion No. 1. From a technical perspective, both the No-MRS and MRS

options are safe.

Although neither option is completely without risk, the Commission determined that the risks are expected to be small and within regulatory limits, and the degree of difference in risks is so small that the magnitude of difference should not affect the decision as to whether there should be an MRS.

Conclusion No. 2. The net cost of a waste management system that includes an MRS would be lower than previously estimated because of delays that have already occurred in the expected date of repository operation, and the likelihood of further slippages of that date.

The economics of an MRS would become more favorable if the repository were delayed and if the MRS were to accept spent fuel as early as possible. These effects would become especially significant if the repository operation were to be delayed beyond 2013, when there will be a sharp increase in the number of nuclear power plants whose current licenses will expire. (See attached Figure 4.3.) If a repository were not in operation by that time, utilities would incur major additional costs that would result from the inability to remove spent fuel from plants being decommissioned. However, as indicated previously, a system with an MRS would still be somewhat more costly on a discounted basis than one without an MRS.

Conclusion No. 3. There are no single discriminating factors that would cause the MRS alternative to be chosen in preference to the No-MRS alternative.

Although the Commission does not find any single factor that would cause it to favor the MRS alternative over the No-MRS alternative, it believes that, cumulatively, there are a number of advantages to justify a central storage

facility not limited in capacity nor linked to the repository schedule and operation. These advantages include storage for emergency purposes; storage for utilities which do not have sufficient space in their spent fuel pools or on-site or which cannot obtain a license for additional at-reactor storage and, hence, might be required to shut down an otherwise satisfactorily operating nuclear power plant; storage for spent fuel from shutdown reactors; economies in the waste management system if an MRS could be completed substantially before the repository; greater redundancy in the system in the event of unforeseen circumstances; more surge capacity to facilitate the flow of spent fuel to the repository; more flexibility in storage options and future waste preparation functions; and assistance in standardization and initiating Federal responsibility for taking possession of spent fuel.

Conclusion No. 4. An MRS linked as provided in current law would not be justified, especially in light of uncertainties in the completion time for the repository. Consequently, the Commission does not recommend a linked MRS as required by current law and as proposed by DOE.

The Commission notes that Members of Congress, other public officials, environmental groups, and many private citizens for many years have expressed concern that an unlinked MRS might be regarded as a de facto repository, and thereby would reduce the impetus for building the repository as expeditiously as possible. Although the Commission does not believe that there is a technical basis for the linkages, the Commission agrees that, in light of congressional and other concerns about a de facto repository, some linkages are justified.

However, the schedule linkage presently in the NWPAA (MRS construction may not begin until the Nuclear Regulatory Commission issues a license for the

construction of a repository) would make it impossible for an MRS to be operational more than three years before the repository. Because of delays already experienced in the repository schedule and continued uncertainty surrounding the repository's location and date of operation, the value of the MRS would be greatly diminished if its construction were tied to the schedule of the repository. Most of the need for an MRS would have disappeared, in that utilities would have had to make other arrangements for storage. (See attached Figure 1.3 for the Nuclear Waste Policy Amendments Act linkages.)

Conclusion No. 5. Some interim storage facilities, substantially more limited in capacity and built under different conditions than the DOE-proposed MRS, are in the national interest to provide for emergencies and other contingencies.

The Commission recognizes the need to provide certain services that would be in the national interest, but which could not be provided by an MRS restricted by the schedule linkages currently in the law. The Commission concludes that spent fuel storage for emergency and other purposes would be in the national interest. Facilities to fulfill this national interest could be more limited in scope and could be built under different conditions than the DOE-proposed MRS.

In view of the conclusions noted above, and in light of its extensive studies and deliberations, the Commission recommends the following:

Recommendation No. 1. Congress should authorize construction of a Federal Emergency Storage (FES) facility with a capacity limit of 2,000 metric tons of uranium (MTU).

In light of the continuing delay in building a repository, the Commission believes it would be in the national interest to have available a safety net

of storage capacity for emergency purposes, such as an accident at a nuclear power plant, which would make it advantageous to have the plant's spent fuel pool available for decontamination of affected parts of reactors and for storage of debris.

If the facility proposed in Recommendation No. 2 were not available, the FES also could be used to store spent fuel from otherwise satisfactorily operating nuclear power plants that would have to be shut down because of insufficient on-site storage.

Because the FES would be designed primarily for emergency use and, hence, would serve as "insurance" for the entire industry, the Commission recommends that the cost of this facility should be paid from the Nuclear Waste Fund, to which all of the utilities which generate power from nuclear energy contribute.

Recommendation No. 2. Congress should authorize construction of a User-Funded Interim Storage (UFIS) facility with a capacity limit of 5,000 MTU. Such a facility would provide storage only, and would be used in addition to the Federal Emergency Storage facility proposed in Recommendation No. 1.

Although spent fuel can be stored safely at reactor sites for as long as 100 years, some utilities may not have space on-site for life-of-plant storage or may not be able to obtain a license for additional storage.

In view of the uncertainties regarding the availability of a repository, the Commission believes it would not be in the national interest to force utilities to shut down operation of otherwise satisfactorily operating nuclear power plants because of lack of storage capacity for spent fuel. Congress recognized this problem by authorizing, in Section 135 of the Nuclear Waste Policy Act of 1982, a Federal Interim Storage facility (FIS). It is the

Commission's intention that the 5,000 metric ton storage facility that it recommends likewise should be available in such contingencies.

This facility also should provide storage for: (a) shutdown reactors at sites where a utility no longer operates nuclear power facilities, and (b) utilities which would prefer to ship spent fuel to this facility rather than retain it on-site.

In view of the uncertainties which have existed as to the time of operation of the MRS and the repository, many utilities with newer reactors have already taken steps to provide needed life-of-plant storage, while others have expressed a preference for providing such storage themselves rather than relying on an MRS. For these reasons, the Commission believes it would be more equitable for the storage facility (UFIS) to be user-funded, so that only those utilities that chose to use the facility would pay for it.

Recommendation No. 3. Congress should reconsider the subject of interim storage by the year 2000 to: (a) take into account uncertainties that exist today and which might be resolved or clarified within 10 years, (b) consider developments which cannot be anticipated today, and (c) evaluate the experience with the two facilities recommended above.

Many uncertainties make it extremely difficult to plan for long-term interim storage of spent fuel. Although the opening of the repository is the most notable uncertainty, many other questions also must be resolved.

The Commission believes that the actions recommended above should be adequate to take care of the needs of interim storage at least until the year 2006. However, by the year 2000, Congress should reconsider the question of interim storage of spent fuel. At that time, Congress should take into account, among other things, such factors as: status of the repository; status

of nuclear power plants; availability of at-reactor storage; utilization and adequacy of the 2,000 metric ton Federal Emergency Storage facility and the 5,000 metric ton User-Funded Interim Storage facility; status of technological developments in the storage of spent fuel; nuclear waste system optimization; and the fee schedule established for the UFIS.

• • •

The Monitored Retrievable Storage Review Commission believes that these recommendations, together with analyses contained in other sections of this report, carry out the Commission's mandate from Congress. If implemented, the recommendations would provide safe interim storage of spent nuclear fuel, would be consistent with the goals of the national nuclear waste management system, and would provide for flexibility and unforeseen contingencies.

The Commission urges Congress, whatever its decision, to act as promptly as possible with regard to interim spent fuel storage, so that DOE, utilities and other affected parties can plan accordingly.

Dr. Klein, Dr. Parker and I want to express our appreciation to the Congress for giving us this opportunity to serve you. We hope that our report will be of assistance to you in resolving a difficult, contentious and important national issue.

Dr. Klein, Dr. Parker and I will be glad now to respond to your questions.

FIGURE 1.3 - NUCLEAR WASTE POLICY AMENDMENTS ACT LINKAGES

(1) construction of such facility [MRS] may not begin until the Commission [NRC] has issued a license for the construction of a repository under section 10135(d);

(2) construction of such facility or acceptance of spent nuclear fuel or high-level radioactive waste shall be prohibited during such time as the repository license is revoked by the Commission or construction of the repository ceases;

(3) the quantity of spent nuclear fuel or high-level radioactive waste at the site of such facility at any one time may not exceed 10,000 metric tons of heavy metal until a repository under this chapter first accepts spent nuclear fuel or solidified high-level radioactive waste; and

(4) the quantity of spent nuclear fuel or high-level radioactive waste at the site of such facility at any one time may not exceed 15,000 metric tons of heavy metal.

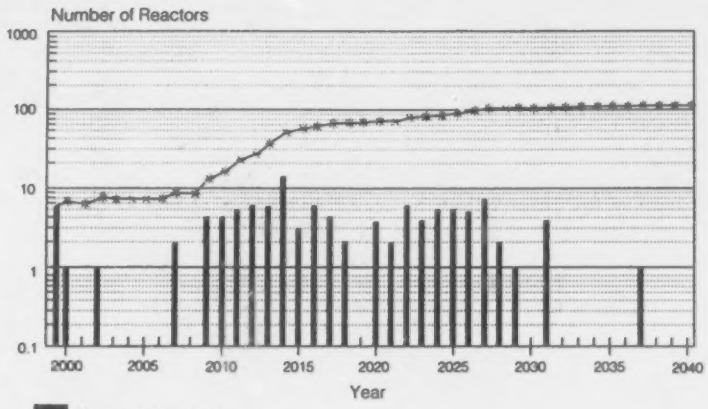
42 U.S.C. § 10168(d)

TABLE 4.3 - COMPARISON OF TOTAL LIFE-CYCLE RADIOLOGICAL EFFECTS OF MRS AND NO-MRS SYSTEMS (2013 REPOSITORY START DATE)

	OCCUPATIONAL EXPOSURE		PUBLIC EXPOSURE	
	Person-Rem	Calculated Cancer Fatalities	Person-Rem	Calculated Cancer Fatalities
No-MRS	26,100	10.4	8100	3.2
Linked MRS (NWPAA)[a]	22,300	8.9	3500	1.4
Unlinked MRS[b]	17,000	6.8	3500	1.4

a Linked MRS to begin operations in 2010.
b Unlinked MRS to begin operations in 2000.

Figure 4.3—Shutdown Commercial Light Water Power Reactors (LWR)[a]



[a] Assumes all reactors will be shut down 40 years after initial reactor startup date.
Data from DOE/RL-88-34, "Spent Fuel Storage Requirements 1988," October 1988, Table A.1.

[b] Includes only shutdown commercial reactors which still have spent fuel stored on-site.

TABLE 5.1 - TOTAL LIFE-CYCLE TRANSPORTATION RADIOLOGICAL RISK

REPOSITORY IN 2013
(54% rail/46% truck from reactors; 100% rail from MRS)[f]

Cases	In-Transit Dose[e]	Handling Dose[e]	Total Transport Dose[e]	Calculated Cancer Fatalities
No-MRS	7,900	4,300	12,200	4.9
No-MRS (dual-purpose casks; 100% rail from reactors)	210	4,100	4,300	1.7
Linked MRS (NWPAA)[a]	3,400	5,600	9,000	3.6
Unlinked MRS[b]	3,400	6,100	9,500	3.8
DOE No-MRS[c]	3,600	N.C.[g]	N.C.	N.C.
DOE MRS[c] Western Strategy[d]	2,100	N.C.	N.C.	N.C.

a MRS to begin operations in 2010.
b MRS to begin operations in 2000.
c DOE cases were presented in the Department of Energy's "MRS Systems Study, Task F: Transportation Impacts of a Monitored Retrievable Storage Facility," May 1989, p.25. The repository in DOE's system handled only 63,000 MTU. MARC systems handled 87,000 MTU. To provide a basis for comparison, these numbers were extrapolated from the actual DOE numbers.
d In DOE's western strategy, western reactors ship spent fuel directly to the repository rather than to the MRS.
e Dose in Person-Rem.
f Except for the No-MRS dual-purpose cask case, which assumes 100 percent rail transport from reactors.
g N.C. = Not Calculated.

TABLE 5.3 - LIFE-CYCLE TRANSPORTATION NON-RADIOLOGICAL RISK

REPOSITORY IN 2013

Cases	Traffic Fatalities	Shipment-miles (in millions)
No-MRS (54% rail/46% truck)	15.5	64.7
No-MRS (Dual-Purpose Casks; 100% rail)	15.5	7.8
Linked MRS[a] (NWPAA; 54%rail/46% truck from reactors; 100% rail from MRS)	15.3	26.9

a MRS to begin operations in 2010

TABLE 6.8(a)

Comparison of Total System Life-Cycle Costs, Nominal Value and Present Value for Selected Cases

Year Repository Starts	No-MRS		Linked MRS		Unlinked MRS	
	Present Value*	Nominal Value	Present Value	Nominal Value	Present Value	Nominal Value
2003	11.6	24.8	12.5	26.9	12.5	27.0
2013	9.2	26.6	9.7	27.9	9.7	26.7
2023	7.4	28.0	7.8	29.5	7.9	27.2

Source: Tables 6.4 and 6.8.

* Present value is in billions of constant 1989 dollars discounted at an annual rate of 4%; nominal value is in billions of constant 1989 dollars.

The CHAIRMAN. Thank you very much, Mr. Radin.

Your statement on page 11, says the Commission does not believe that there is a technical basis for the linkage, but the Commission agrees that, in light of congressional and other concerns about a de facto repository, some linkages are justified.

What linkages are justified?

Mr. RADIN. In our recommendations, we have recommended a 5,000 metric ton facility, and we think that, in itself, is a linkage, because it could hardly be regarded as a de facto repository. A 5,000 MTU facility would only accommodate about 6 percent of the total amount of spent fuel that is likely to accumulate during the life of all existing operating reactors and those that are now planned for completion.

So we think that is, of itself, a linkage and should allay any concerns about this facility being a de facto repository.

The CHAIRMAN. Well, could you tell me why a 15,000 ton storage facility would be regarded as a de facto repository?

Mr. RADIN. It is a matter of judgment, Senator Johnston. There have been a lot of concerns expressed about a 15,000 metric ton facility. And the fact is that Congress, although there were differences of opinion, did impose these linkages on a 15,000 metric ton facility.

We felt that a 5,000 metric ton facility would be adequate for the foreseeable future, or at least until the year 2006. And we felt that that should give adequate assurance that the Congress is not embarked on a facility that would replace a permanent, geologic, underground repository, which we think should be the goal of the national waste management program.

The CHAIRMAN. Now, let us say by the year 2000, how many years of waste would 15,000 represent—or should I say, what is the rate of waste available for storage by the year 2000?

Mr. RADIN. It is accumulating at about 2000 metric tons a year, Senator Johnston. And we figure that by the year 2006, there will be a need for about 9,000 metric tons of storage, in addition to the amount that is now available in the pools that exist.

The reason that we selected the 5,000 metric ton facility, and again, it was a judgment call, was that on the basis of the testimony we have heard, we know that some utilities are providing for their own storage on site. And we have estimated that perhaps about half of the utilities would provide storage on site, and therefore we felt that 5,000 metric tons would be adequate to take care of such needs as we foresaw for the period up to the year 2006.

The CHAIRMAN. All right. You say there will be 9,000 needed by the year 2006?

Mr. RADIN. Yes. In addition to the storage capacity that is now available in pools.

The CHAIRMAN. And you are aware that Yucca Mountain may not be open until year 2010. Then, your 5,000 ton storage facility, which you propose, would not take care of the waste, would it?

Mr. RADIN. It would not take care of all of the waste, no. But we have had testimony from some utilities that they plan to provide storage on site, because of the uncertainty of the repository program and the uncertainty of the MRS itself.

The CHAIRMAN. Now, is that a better proposal than to have an MRS?

Mr. RADIN. To have it on site?

The CHAIRMAN. Yes.

Mr. RADIN. I think that that is up to the utilities to decide whether or not they would prefer to have storage on site or whether they would prefer to move it to an MRS.

The CHAIRMAN. But the question was put to the Commission, should you have an MRS? And the Commission says no, you should not have an MRS. And implicit in that is that you do not need an MRS. And I say do they need it? And you say, well, you will need 9,000 by the year 2006; the repository may not be open until the year 2010.

So, add to that another 8,000 tons at 2,000 tons a year, that is 17,000 tons that you will need by the year 2010, and you recommend for only 5,000 tons. What happens to the other 12,000 tons? I guess it is put on site.

And the question is, is it better to put it on site than in an MRS?

Mr. RADIN. The only way that you could have all the advantages of an MRS is to have it completely unlinked, both in capacity and in linkage to the time of construction of the repository. And at least it was my judgment, speaking for myself, that it was unrealistic to assume that you could build such a facility.

So we are providing for what we anticipate will be the need for the time being.

The CHAIRMAN. Well, that is unrealistic. Should we? I mean, it is for your Commission to tell us should we do it or should we not.

Do you think it is unrealistic to pass new legislation to have two new repositories? Do you know what we have been through to get these things passed into law? And you say have two more. That is realistic?

Mr. RADIN. They are much smaller than the facilities that were originally proposed.

The CHAIRMAN. Well, what should we do, with respect to science? We have got 12,000 tons now not accounted for and no place to put it.

Senator BUMPERS. Wait a minute. What did you say, 12,000 tons unaccounted for? Oh, you are talking about——

The CHAIRMAN. What they have said is that by the year 2006, there will be 9,000 tons for which there is not presently a place to put it.

Senator BUMPERS. No place to put it.

The CHAIRMAN. And Yucca Mountain may not be open, as I understand it, until the year 2010. That is a soft number, it probably means later than 2010 at the rate they are going.

And you have got 2,000 tons a year. Listen, Senator Bumpers, I am telling you where this came from. You have got 2,000 tons a year that is coming out, so between 2006 and 2010 you will have another 8,000 tons, so that makes 17,000 tons, and they are recommending a new facility that has a capacity of 5000 metric tons.

Senator BUMPERS. Wait a minute. You recommended a federally built 2,000-ton repository.

Mr. RADIN. That is for emergency purposes.

The CHAIRMAN. We hope you do not use that.

Senator BUMPERS. So, you are saying you have 12,000 tons with no place to go?

The CHAIRMAN. And the question was what do we do with that? Is it better to store it on site or at an MRS? And that is the question.

Senator BUMPERS. Would you add this to your question, Mr. Chairman—that is, what is the relative cost? Is there a cost differential between them doing it on site and building a central storage facility?

Mr. RADIN. Our study showed that in all cases if you use a discounted calculation that an MRS was more expensive than a no-MRS option. If you use an undiscounted calculation, you come fairly close to the break-even point in the year 2013.

The CHAIRMAN. It is cheaper for the utilities to do it on site than to store it at an MRS?

Mr. RADIN. That is correct.

The CHAIRMAN. Dr. Parker?

Dr. PARKER. That is on an undiscounted basis, Senator Johnston. Discounted basis, if you look on the last page of the handout, those numbers are summarized and you can see precisely the values, for each of the repository art dates for the no-MRS, for the linked MRS and for the unlinked MRS for both the present value method, discounted value, where it does not ever exceed the MRS cost, and then the unlinked where the crossover point is about 2013. As you can see, it is $100 million difference for an unlinked MRS, more expensive than the no-MRS case.

But if I could, Senator Johnston, respond to your question, none of us know exactly when any of these facilities will take place, as you know. That is one of the great problems that you have wrestled with and we have had to wrestle with, and so we have done a whole series of studies, a whole series of scenarios as we have called them. Some of the scenarios are outlined in the figures on pages 60 and 61 which show where the spent fuel will be if we have in this case an MRS in the year 2000, a repository in 2003 which is the linked case, the case that is in law right now. And the table below it shows exactly where the spent fuel would be located at that time.

We have also shown on page 61 in Figure 6.2 if we do not have an MRS and we do have a repository in 2013, again, where this fuel would have to be stored, and you can see in that case that by the year 2010 there would be approximately 14,000 MTU of spent fuel at the reactors and that the pool storage would be something on the order of 45,000 MTU.

Our understanding was that we were not wise enough, nor do we believe anybody else is wise enough to predict all the social, political, technical and scientific facts that will come from further investigation of Yucca Mountain and political developments in the state. And so, we felt that as in many other pieces of legislation that Congress ought to have the opportunity to make a mid-course correction sometime later and our recommendations would take care of this situation in the near term.

And if you would look on page 91 on Figure 8.1, you can see that the amount of fuel that is necessary to be stored outside the pool in these early years is relatively a small amount.

So, what we are saying is let us take care of that situation right now, make sure that we can handle all the problems that arise over the next ten years, and then look at what has taken place, whether the political situation has changed, whether the investigation at Yucca Mountain shows it's a suitable site or not and then make a decision as to what is the best course for the country at that time.

The CHAIRMAN. Do I understand effectively what you are saying is that we need an MRS but yours is too big? Reduce it in size from 15,000 tons to 5,000?

Dr. PARKER. What we are saying is if there were a negotiator and if the state of Nevada changed its attitude towards the repository and if the repository came on line at some earlier date, then there would not be the need for a large-scale MRS.

The CHAIRMAN. If it came on line when?

Dr. PARKER. If it came on line at an early time.

The CHAIRMAN. Like 2003 or earlier than 2003 or earlier than 2010?

Dr. PARKER. Earlier than 2010. This would take care of the spent fuel to the year 2006, our recommendations.

The CHAIRMAN. So, you are saying we need an MRS, but it needs to be smaller, and it needs to be financed differently from the way we finance it?

Dr. PARKER. Well, we had testimony from a number of the utilities, TVA, Rochester, and a number of the others said that they would prefer to do it themselves, that they have already made that commitment and they felt that their ratepayers would be taxed for a facility that they had already spent money on and would not use.

The CHAIRMAN. What percentage of the utilities oppose this?

Dr. PARKER. Two testified against an MRS. Three, actually.

The CHAIRMAN. And did that represent the majority or was it more logically appealing to you?

Dr. PARKER. We thought that consideration should be given to their views and the fact that they have made those expenditures.

Mr. RADIN. And we know that other utilities are now engaging in dry cask storage or are planning to do so, so that we felt we should take that into account in our recommendations.

Also, I might add that at the time of our report we had no first-hand knowledge of when the repository might be in operation. Your statement this morning is the first official word that we have had that the repository might be delayed until the year 2010.

The CHAIRMAN. That is not official. It is an official rumor.

Well, if you took away the question of when the opening of the repository, when it is going to open—so, let us say it opens on time, then you would say we need no MRS.

The MRS is simply, in your view, to be available until the repository opens. Am I correct on that? In other words, that is the only justification for it. Its need to collect, to service, a point to collect the waste, to package them, to cool them down before you put them in the repository. Those are not considerations?

Mr. RADIN. Some of those functions cannot be determined until the site of the repository is determined, because you cannot do the packaging function, for example, until you know what host rock they will ultimately reside in. So that the Department of Energy

itself now recommends that the MRS facility be only a storage facility and not have rod consolidation or packaging functions that were originally proposed because of the uncertainty as to the ultimate location of the repository.

Dr. PARKER. Senator, we have listed a whole variety of reasons why we think an unlinked MRS has desirable features, and those are in our report.

If I have a moment——

The CHAIRMAN. Would you tell us what those desirable features are. Just the principal ones.

Dr. PARKER. If we look on page 100 under conclusion number 3, we list approximately ten reasons why we find that an MRS whose schedule of operation and capacity is not linked to the repository would serve many useful purposes. One is supplying storage for emergencies. Second is providing storage for utilities that have insufficient space in their spent fuel pools that would otherwise have to be shut down, furnishing storage for spent fuel from shutdown reactors, creating economies in the waste management system.

If the MRS could be completed substantially in advance of the repository allowing greater redundancy in the system in case of unforeseen circumstances, offering more surge capacity in the system, providing more flexibility in storage options and future waste preparation options, assisting in standardization and initiating federal responsibility for taking possession of spent fuel, we believe all of these are important items but that not a single one of them by itself would justify an MRS. But, cumulatively they point to the value of an unlinked interim storage facility.

The CHAIRMAN. We heard a lot of testimony through the years on the fact that it would be useful to cool down these rods before you put them in the host rock. I do not see that mentioned here. Is that not a factor?

Dr. PARKER. That statement is in our report, sir. I will have to find the exact page, but we have a statement in that the European countries are all taking that approach, and I personally feel that that is the case. And we unanimously as a commission have inserted a statement of that sort in the report. I will find that page for you.

The CHAIRMAN. Is your 5,000-ton facility sufficient to serve that purpose?

Dr. PARKER. It is an interim solution, sir, and so in the year 2000 the Congress would have to reexamine what the status of the repository is and a wide variety of other considerations and then could make that choice.

But, as you know, a lot of that fuel has already been stored for 10, 15, 20 years, and so it is cooled to the extent that it is feasible.

The CHAIRMAN. When we get going on this, when the fuel is ready to come out of reactors, not that which has been stored, a 5,000-ton facility would not be sufficiently large for that, would it?

Dr. PARKER. I don't believe it would be. It depends upon whether you take fuel out of the spent fuel pool and insert the new fuel in the pool and allow it to cool there for a while before you then send it on to the MRS. But that decision would be made at a time when you know the repository is going to be in place.

I think one of the things that drove us in the system was that if we take no action now, then we are saying that we will store the spent fuel on site at reactors into the distant future until there is a repository. And we feel there are advantages to not doing that.

The CHAIRMAN. I confess I have not read the full report. I did not get it until yesterday. I look forward to it. Therefore, you will understand my being confused at this point.

Let me turn it over.

Senator ROCKEFELLER. Mr. Chairman, I have to make an apology. Unfortunately, the conferees in the Senate Finance Committee conferees are meeting, which is most upsetting to me, because this is an issue that I feel strongly about that has a lot of meaning to West Virginia.

I would ask permission to insert a statement into the record and also to submit in writing a series of questions that I would like to have answered.

The CHAIRMAN. Of course.

Senator ROCKEFELLER. I deeply regret that I cannot follow through on this. It is extremely important to us.

[The information appears, starting on p. 71.]

The CHAIRMAN. Senator McClure.

Senator MCCLURE. Thank you, Mr. Chairman. I am sure all of us after having had an opportunity to study the report more fully, will both understand it better and also perhaps be able to ask better questions than we can after a rather preliminary review of it.

I want to focus on just a couple of things if I can in the time available to me right now. Reading your letter that is attached to the executive summary under which you are transmitting the report to the Congress at the bottom of the first page, you make a statement which I believe I understand but I want to make sure I understand. "Although the commission does not believe that there is a technical basis for linkages, the commission concludes that some linkages are justified."

Now, if I could restate that in a slightly different way, on the basis of technical considerations alone, you would say no linkage is justified?

Mr. RADIN. That is correct.

Senator MCCLURE. But you conclude that some linkages are justified? I jump to a conclusion that you regard that those linkages are acquired by political and judgmental values?

Mr. RADIN. I would say judgmental values, yes, Senator McClure.

We found that throughout our studies while we were asked to make our conclusions and recommendations on the basis of technical considerations, we also felt that you could not look at this issue without making some other judgmental decisions.

In listening to testimony throughout the country and in observing what Congress itself has done on the linkage issue, we felt that some linkages could be justified and, as I said, the primary linkage is that this larger storage facility of 5,000 MTU, the size of that facility itself would be a linkage. Also, the fact that it would be user-funded, I think, would give some assurance that this facility would not be one that could be considered as a de facto repository.

Senator McCLURE. All right. The recommendation that you make for these two other facilities are really kind of insurance policies?

Mr. RADIN. That is correct, sir.

Senator McCLURE. And you think the cost of those facilities is worth the amount of assurance and safety that is obtained?

Mr. RADIN. That is correct.

Senator McCLURE. With that in mind, I know you have a lot of different tables in your report, but you attached one to your statement, and I will use the one that you attached to your statement because I have had a little more chance to look at that than I have to analyze all the tables you have in the report.

The last table attached to your report gives relative costs of a no-MRS and linked MRS and an unlinked MRS. As I look at the differences between those, those differences in cost range from 1 to 2 percent of total cost.

Mr. RADIN. Yes, sir. I think that is about right.

Senator McCLURE. Now, is that less expensive or more expensive than the alternative you have suggested?

Mr. RADIN. In all cases using a discounted value of 4 percent, the no-MRS option is less expensive than the MRS option. If you use the nominal value, then about the year 2013, the costs are about the same, and on a nominal value there is about $800 million advantage——

Senator McCLURE. If we built an MRS and if you look at this table, you would be talking about costs of 1 to 2 percent more than another alternative.

Now, you have suggested an alternative in which you construct two facilities that admittedly have very little capacity but you think might be done. Those have costs?

Mr. RADIN. Yes, sir.

Senator McCLURE. And are the costs of building those facilities included in this table?

Mr. RADIN. No, they are not.

Senator McCLURE. And what is the cost of building those two facilities?

Mr. RADIN. Well, the cost numbers are not——

Senator FORD. Dr. Klein, do you have anything to say?

Dr. KLEIN. I think when you look at the cost factors, what really happens occurs after 2013, after that period is when the current licenses of several reactors will expire, and at that time if the only option then is at-reactor dry storage, the costs of maintaining those facilities are on the order of $2-$3 million per reactor per year, and that is a significant cost that typically had not been accounted for in some of the DOE studies.

Senator McCLURE. I was trying to compare the cost of an MRS program linked or unlinked with the cost of the program that you have suggested of building two facilities, and if I understand it correctly—and correct me if I am wrong—the cost of the facilities you suggested is not included in this table.

Mr. RADIN. That is my understanding.

Senator McCLURE. You are willing to pay that cost because you think there is some assurance in those facilities or to put it in another way, an insurance policy for our activities.

The question I am asking is, is the cost of building those two facilities greater or less than the additional cost of an MRS program?

I will tell you, my own conclusion is you suggested a more costly alternative.

Mr. RADIN. No, sir. I do not think it would be more costly.

Senator MCCLURE. I look at the difference in no MRS and a linked or unlinked MRS. In 2023 that difference is $400 million in one case and $500 million in the other case, and you are not going to build these two facilities for those figures.

Mr. RADIN. Senator McClure, if I may, could I ask our chief economist to respond here, Dr. Allen Pulsipher?

Dr. PULSIPHER. I think the answer to the question depends on when the facilities come on line.

Senator BUMPERS. Pull that microphone up closer to you, please.

Senator MCCLURE. Well, look at either present value or nominal value. I am just giving you the figures in 2023 on present value according to your table. On nominal value, the difference is $1.5 billion in one instance and a $800 million savings in the other, and that is without considering the cost of the alternative you suggested.

Now, if I am right, you suggested not only the most costly alternative, you have also suggested the one that has the least insurance value to us.

Dr. PULSIPHER. I think what we are saying is if the facilities that we recommend were built early, they would provide the insurance.

Senator MCCLURE. Two and a half to three and a half years of capacity.

Dr. PULSIPHER. No, it would be more than that.

Senator MCCLURE. At 2,000 tons per year, and you are talking about five in one and two in the other, making a total of seven.

Dr. KLEIN. Except that the difference, Senator, is that certain reactors have the capacity to store some of their fuel in existing pools. So, when you compare what an MRS facility would need, it is that amount of fuel that would have to be put in dry storage, either at the reactor site or at an MRS. So, 2,000 a year is not necessarily the amount that would be going into dry storage per year.

Senator MCCLURE. I understand that, but the capacity you are suggesting for the two facilities you have suggested is, if I understand it, 5,000 tons and 2,000 tons.

Mr. RADIN. Right.

Senator MCCLURE. And if we are producing at the rate of 2,000 per year, during that period of time, my mathematics come out two and a half to three and a half years.

Dr. PULSIPHER. The 5,000 MTU facility is user funded. It is up to the utilities whether or not they want to provide for dry storage on site or whether they want to pay for the user-funded facility.

Senator MCCLURE. I understand that, but I am looking at total costs according to your figures. And, again, is this table—I assume you chose this table to put together with your statement because the table means something.

Dr. PULSIPHER. That table compares the no-MRS, the linked MRS and the unlinked MRS alternatives over a significant time period.

Senator MCCLURE. And the differences in cost between the three programs is somewhere between 1 and 2 percent of total cost.

Dr. PULSIPHER. It's about 6 percent on a discounted basis between the alternatives.

Senator MCCLURE. On a discounted basis?

Well, look at the bottom line, 2023. The difference between $28 billion and $27.2 billion.

Dr. PULSIPHER. That is on an undiscounted basis. I said on a discounted basis. If we take into account the value of money over time.

Senator MCCLURE. This says it is on present value in billions of constant 1989 dollars discounted.

Dr. PULSIPHER. The present value is 7.4, 7.8, 7.9. The nominal value is the one you cited 2827.2.

Senator MCCLURE. The difference is smaller on the present value. If it is discounted, the difference is $400 million in one case and $500 million in the other case. Is that correct?

Dr. PULSIPHER. That is correct.

Senator MCCLURE. Those costs are less than the costs of building the facilities you suggested.

Dr. PULSIPHER. The costs cited in the report are on a nominal value basis.

Senator MCCLURE. It does not say nominal value basis in this chart, then.

Dr. PULSIPHER. On a nominal value basis if you compare it for the period in which you want insurance, that is when you are trying to avoid having otherwise satisfactorily operating reactors shut down.

Senator MCCLURE. That I understand. But the insurance you get with either a linked MRS or an unlinked MRS, you buy more insurance at lower cost.

Dr. PARKER. Senator, if I might respond a little, I think we should recognize it is the operational cost of the MRS or the interim storage facility that adds up to the major part of the cost, the cost of building the facility itself is not the major part of the cost.

Senator MCCLURE. I understand that. It is going to cost you more to operate an MRS than it is the facilities you suggested. That would be a different cost factor than the ones given here.

Dr. PARKER. It depends where it is built and how it would share, if it could share some of its facilities and if it could share some of the security costs.

Senator MCCLURE. I understand that. I still say if I can read these figures and understand the figures at all, you have adopted the policy with less insurance value at a higher cost, and I do not understand that. Let us just take out of the discussion for a moment how much it would cost to build and operate the two facilities you have suggested and just look at the differences in cost, whether it be on a present value or a nominal value basis, what value assurance is that to this country to have a monitored retrievable storage facility of larger size than the one you have suggested?

Dr. PULSIPHER. The facilities that we are talking about here, the FES and the UFIS, the cost to construct those would be about $400 million in undiscounted dollars for the FES and about $500-$600 million for the UFIS.

The UFIS, however, is user-funded.

Senator MCCLURE. So is the MRS.

Dr. PULSIPHER. It would take the place of funds that would be expended by the utilities for at-reactor storage. Therefore, it is not a net addition to the cost of the system. The MRS would cost about $1.5 to $2 billion.

Senator MCCLURE. You say it is user-funded. That means they collect from their customers an additional amount of money in order to pay for it.

Dr. PULSIPHER. That is right. It costs the utility that chooses to use the UFIS rather than at-reactor storage an equivalent amount of money. We would assume, if they chose to build a UFIS, they would think that would be a cheaper alternative than providing storage at the site.

Senator MCCLURE. And they are already being assessed and paying into the fund which is supposed to be building the facilities.

Dr. PULSIPHER. That is right. They are paying for those facilities as well as the repository, but the MRS only is about 10 percent of the total cost. They are certainly not just paying to build the MRS. They are building the entire system.

Senator MCCLURE. Well, if you have got a better explanation I hope you will provide it for the record, because I certainly do not understand these figures to indicate that it is a less costly alternative.

It appears to me to be a more costly alternative for a system that has less storage capacity, and I do not mean to be boring about this, but if you have got figures that say that is not true, provide them for me.

Mr. RADIN. Senator, let us do that. I think you have raised some questions that we need to examine further and we would like to submit some additional information for the record to clarify this point.

Senator MCCLURE. Thank you. I would just state my own feeling, and I have felt this way for a long time. When you get around to that geological storage you are being asked to give assurances to the public that we can assure perfect safety for tens of thousands of years.

You know the process as well as I do, of all the intervenors and all the fears that are raised and promise us this and assure us that and guarantee against this, for tens of thousands of years. That is what a geological repository is.

Those a very, very difficult assurances to make absolutely and MRS is a much easier task to give the assurances with respect to the time frames you are talking about, whether it be ten years or 50 years or 100 years, whatever it might be.

Those are relatively finite periods of time and the human experience is such that we can make very good assurances over those periods of time. To me, that has always seemed more likely to be done than the geologic repository.

As I look at things that happen, nothing happens in the time frame you believe that it will happen. It always takes longer, if it can ever be done, and this country is indulging itself in some kind of an orgiastic ritual, in feeling good about how scared we are.

I do not quite understand that mindset, but I think we have it, and I think Yucca Mountain is just beginning to be exposed to those fears. I do not know the source of the estimate that it would

open in 2010, but I have learned a long time ago that every prediction you make is wrong on time.

Mr. RADIN. Senator, I do not want to minimize at all the economics of MRS or what we have recommended. We are very conscious of the economic factors, but in the final analysis we felt that economics alone should not be the driving factor in our decision.

The recommendations we have made we felt would take care of the needs at least until the year 2006, and at that point some of the uncertainties that you have referred to hopefully by the year 2000 might be resolved and Congress could take another look at this issue.

Senator MCCLURE. Well, Congress will take another look at it every year so long as there is any opportunity to kill a program that has any promise, and that is exactly what has been happening for years and that is not going to change. That is why I have believed that the MRS was the course we ought to be trying to further, because that can be done.

I think if I read you correctly, and I do not mean to put words in your mouth, if I read you correctly, you think some linkage is justified and that is not a technical evaluation, that is probably a political evaluation, if I can use that term.

Yet you are unwilling to say that an MRS is justified even though it provides more storage capacity for a longer period of time at lower cost than the ones you are suggesting. That seems to me to be a gain that is motivated certainly not by economics, as you indicate, but by your judgment of the political evolution of these matters.

You are assuming, if I get it correctly, that these two facilities you suggest are politically doable and the MRS is not politically doable so let us cancel the MRS and transfer to something we might be able to accomplish. Did I read you right?

Mr. RADIN. I will speak for myself, Senator McClure.

In evaluating the MRS on an unlinked basis, you would have to assume that all the advantages would be obtained, first of all if there were no linkage in time to the repository and if there were no limitation on the capacity of the MRS.

In the computer runs that we have made, which show the maximum advantage of an MRS depending upon what year you assume the repository may be in operation, you would have to assume that the capacity of the MRS to take the full advantage of it might go as high as 36,000 to 70,000 metric tons.

That, then, in my estimation at least, would be of such a magnitude that there would be a large body of opinion that would conclude that would be a de facto repository. Now, that is a judgment factor. I think that reasonable men and women can have differences of opinion on that issue.

That is my own personal opinion, that an unlinked MRS of that magnitude would be extremely difficult, if not impossible, to build, considering no linkage in time and no limits on the size of the facility.

Senator MCCLURE. You are talking impossible only in political terms?

Mr. RADIN. Yes, sir.

Senator MCCLURE. That is neither technical nor financial?

Mr. RADIN. That is right. We have said from a technical standpoint there is no reason at all for the linkages. From a technical standpoint there is no reason, no basis from a technical standpoint, in the linkages.

Senator MCCLURE. Well, I have always believed that if indeed you build an MRS that is an option you would then be able to assure in the future of moving to a geological storage. Members of the House of Representatives in particular have believed that if you build an MRS and it works, then there is no need—a future Congress will determine that there is no need to spend the money on the geological storage and therefore you would have de facto permanent storage.

I know what their argument is. I have heard it repeatedly over the last half a dozen years. But that is a decision that can well be made. If their objection to an MRS is a valid objection as a permanent repository, it would still be a valid objection and a driving force towards building the geological storage.

I have been willing to go along with the other body in terms of a dual track of both the MRS and geological storage as a means to assure them that the MRS was not intended to and would not become a permanent storage.

We will be spending the money so that by the time you get to your 30,000 tons or whatever else it may be, there is a geological storage available and ready in which you can then transfer the materials. We are doing that on both bases.

Now, I do not know how better to give them the assurance, the people that fear the permanency of the MRS, than to spend the money to build the geological storage, and we are doing that. But it also seems to me that we ought to be prudent enough to take care of the waste until that is done, and while they are skeptical of the permanence of the MRS, I am skeptical of our ability to get a geological storage on line.

Mr. RADIN. Well, senator, I would only add that first of all we feel that the program we are recommending would take care of the needs at least until the year 2006, and we cannot ignore the fact that the Nuclear Regulatory Commission has stated that fuel can be stored safely at site for as long as 100 years, so it is not as if there is no option at all for storage until such time as the repository is completed.

Senator MCCLURE. I realize that. My own reaction is that that is not the preferable alternative. It is one that we can use. I would think that those people who are really concerned about the hazard of storage of nuclear waste would be completely orbital about having dozens of sites around the United States instead of one or two.

But you see, that does not really happen, does it? The reason they do not become orbital about that is because only by tolerating that can they kill off the other alternatives, and that is their goal, is to kill off the other alternatives. There is no logic to it, either political or economical, or technical, and so you have to divine what their purpose is,

When you look at the complete irrationality of the position, I am still concerned that indeed we are taking the highest cost, highest

risk options rather than trying to minimize the risks and minimize costs.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator McClure. Senator Ford.

Senator FORD. I do not know whether there is anything left for me or not.

The CHAIRMAN. Dr. Parker, did you want to reply?

Senator FORD. I yield to you, doctor. Go ahead.

Dr. PARKER. I was going to try to perhaps help Senator McClure understand exactly what we have done and what we have not done, because we did not extend the lifetime of what we have recommended beyond the year 2006.

We have not carried out the calculation as to what the Congress might decide to do in the future and so those figures which would be comparable to the figures in the table that you have referred to are not available, because we do not know what the Congress in its wisdom will decide to do at that future time. So there is no direct comparison between those two.

If you like, we can have our staff run off a series of scenarios as to what the Congress might decide to do based upon when the repository might or might not be opened. That certainly is possible. We have the technology available to do that and will be happy to do that, senator, if you would like that.

The CHAIRMAN. Senator Ford?

Senator FORD. Mr. Chairman, thank you. I was interested in reading the Energy Daily. I get in fairly early and my staff gets in earlier than I do and they mark up a few things. The article states that Congress created the MRS Commission in the 1987 Amendments to the Nuclear Waste Policy Act as a way to resolve, and I underscore resolve, an impasse between supporters and opponents of the MRS.

The Commission report is expected to be highly controversial, particularly that recommendation to sever the link between the MRS and the geological repository.

The Environmental Action Foundation immediately blasted the Commission's report, and I quote from that. It says, "the most confused noncontribution to a dialogue we have ever seen," but the Edison Electric Institute says it supports the Commission's conclusions that an MRS would be justified if unlinked from the permanent repository.

Now, Mr. Chairman, for the record, tell us what linkage is? We have talked about linkage as if everybody knows what we are talking about this morning. I think I do. I am supposed to. But just for the record, tell me what linkage really is.

Mr. RADIN. Well, as I understand linkage——

Senator FORD. You are supposed to be the expert.

Mr. RADIN. Well, I appreciate the implied compliment.

Senator FORD. You take it when you can get it around here. [Laughter]

Mr. RADIN. As I understand linkage, Senator Ford, linkage is a way of trying to assure that an interim storage facility will not foreclose or detract from the building of the permanent repository, which is intended to be the ultimate solution to the problem of storage of nuclear waste.

Senator FORD. All right. Let us look at your conclusion four and return to that, if we may. Your statement says some linkage would be justified and we get back to where Senator McClure is coming from.

Did the Commission focus on which linkages would be appropriate and which ones would not? For instance, did you consider whether it would be effective to maintain no linkage related to capacity limitations but drop the linkage related to the repository schedule?

Mr. RADIN. Well, by inference I think you could conclude that since we recommended a 5,000 MTU facility we have concluded that the capacity linkage, at least for this size facility, would be adequate assurance. But obviously other groups do not take great comfort in that recommendation.

Senator FORD. Well, the interim storage facilities recommended by the Commission would be limited, as we have said, now to 2,000 metric tons for emergency storage and 5,000 metric tons for user-funded interim storage.

Now, Mr. Chairman, do we not already have the money for the MRSs?

Mr. RADIN. Do we have the money for the MRSs?

Senator FORD. Yes.

Mr. RADIN. You mean in the Nuclear Waste Fund?

Senator FORD. Yes. Have we not been collecting money for that?

Mr. RADIN. Yes, sir, that is true.

Senator FORD. Now your FES would be an additional charge, would it not?

Mr. RADIN. Let me explain it this way, Senator Ford. Some utilities are already building——

Senator FORD. I have heard that before in your economist. I am like Harry Truman. I want a one-armed economist. On the one hand, it is this, and on the other hand it might be that. I would just like to have one straight answer. We have already collected the funds to build the MRS and now you are saying that you link based on how much storage can be done on-site as it relates to FES.

Why should we have a funded storage facility by an additional charge on the consumer? Are they not paying now?

Mr. RADIN. They are paying for that, but primarily for the repository.

Senator FORD. You mean there are no funds there for an MRS?

Mr. RADIN. Yes, there are funds for the MRS.

Senator FORD. So they are paying for both then, are they not?

Mr. RADIN. But under the proposal that we are making all utilities would only be paying for their own storage, and those who use the user funded interim storage would be paying for it. Under the present plan, some of the utilities would be paying into the Nuclear Waste Fund for an MRS that they would not ultimately use.

We think this is a more equitable plan. Everybody would be placed on parity.

Senator FORD. Yes, but it seems like parity. Everybody is paying and then some do not have the space, so they have to pay more. They do not have space for storage, and so therefore they have to use your FES and therefore they have to charge their consumer more. Is that not correct?

Mr. RADIN. They would have to pay for it in any event.

Senator FORD. Could they not send it to the MRS?

Mr. RADIN. But they are paying for it one way or the other.

Senator FORD. They paid for it one time. They have already paid for the MRS. Why send it to FES and then to the MRS—and A, B, C and so forth?

Mr. RADIN. Well, I can only say that they would be paying for it once. They are not paying for it twice.

The Chairman. Are they not being assessed a fee now?

Senator FORD. They are being assessed a fee now and then if they go to the FES that is another charge.

Mr. RADIN. The only thing that they would be paying for out of the Nuclear Waste Fund in our recommendation would be for the FES, which we regard as sort of an insurance policy for the entire industry, and for that reason we felt that that cost should be shared by the entire industry through the Nuclear Waste Fund.

Senator FORD. So you are going to take the Nuclear Waste Fund and build the FES?

Mr. RADIN. That is correct.

Senator FORD. And then you are going to charge for storage in the FES?

Mr. RADIN. The FES or the UFIS?

Senator FORD. Hell, I do not know. [Laughter]

Senator FORD. Why don't you just spell it out instead of using all these initials? What is the UFIS?

Mr. RADIN. That is the 5,000 metric ton facility.

Senator FORD. And that 5,000 metric ton is a user-funded interim storage?

Mr. RADIN. That is correct.

Senator FORD. Now does the user-funded come out of the assessment already, or is that assessment going to stay over here and you are going to get a user-funded for the FES?

Senator MCCLURE. UFIS.

Senator FORD. UFIS. It is bound to be useless. [Laughter]

Mr. RADIN. The user-funded facility obviously, by the very name of it, would be paid for only by those utilities that used it.

Senator FORD. Well, some would be paying twice, because they are assessed, and others would be charged——

Mr. RADIN. The only ones who would be paying twice—well, everybody would pay for the first 2,000, but for all of their storage the utilities would be paying only once. They pay for it either through the facilities they build on-site or for the applicable portion of the cost of the user-funded facility.

The Chairman. In theory all would be paying twice. In practice, probably all would be paying three times: first, the assessment they are presently paying; secondly, the additional assessment that they are going to have to pay because they are not going to have enough money to build the repository; and third, this new assessment for the 5,000-ton facility. Is that not right?

Senator FORD. Mr. Chairman, I am going to withdraw. I am getting confused not only by the answers but by the danged questions. [Laughter]

Senator FORD. How many facilities will have on-site storage?

Dr. KLEIN. Dry cask storage?

Senator FORD. Whatever. You know, the general public out there, when you go to put nuclear waste on-site, they do not know whether it is dry, wet or indifferent. So how many sites will have some sort of storage?

Dr. KLEIN. All sites. All sites have wet storage.

Senator FORD. That is the so-called swimming pool or cooling pool. How much dry storage?

Dr. KLEIN. It is time-driven. If you look at 1995 as an example, there will be 14 reactor pools that will need additional dry cask storage. By the year 2000 that number goes up to 36. By the year 2005 it is 52. So it is time-driven.

Senator FORD. How many utilities do we have?

Dr. KLEIN. We have 110 reactors. I think in terms of the number of utilities——

Senator FORD. 110 reactors. Okay. That is where your storage would be?

Dr. KLEIN. Right. And there are about 70 sites.

Senator FORD. So you have got 52 of those, almost 50 percent of them, by the year 2005, I guess is what you said. You would have half of them that would require on-site storage, dry storage.

Dr. KLEIN. Correct.

Senator FORD. Well, Mr. Chairman, I think I am going to have to study this some more. I thought I read all the papers I received and tried to do everything I could. I got pretty good help from the staff. They gave me lots of things. And I am somewhat concerned, and I agree with Senator McClure that it is in a position where those that oppose it will have a lot of linkage to opposition.

So I hope we can work it out. I had confidence in the Commission, and still do, and they probably in their own mind—was your Commission unanimous in all its decisions?

Mr. RADIN. Yes. All the recommendations.

Senator FORD. All the recommendations were unanimous?

Mr. RADIN. Yes, sir.

Senator FORD. And were there any recommendations by the Commission that you dropped because you were not unanimous?

Mr. RADIN. Well, I think we had a lot of discussion during the course of the meetings.

Senator FORD. That is not really what I said, Mr. Chairman. I said, were there any recommendations by the other Commissioners that since you could not be unanimous you dropped them?

Mr. RADIN. Oh, we obviously—maybe it is not obvious. We had some compromises.

Senator FORD. I understand that, coming from the State of Henry Clay. But you compromised your positions, some of you, in order to get a unanimous decision.

Mr. RADIN. I think that is a correct statement, yes, sir.

Senator FORD. What was the hardest one to compromise—all of them?

Mr. RADIN. I think there were some differences of opinion, Senator, as to just how much—there were differences of opinion as to the issue of a de facto repository—in other words, whether or not that was a valid issue or not. Some members of the Commission—I think I have already expressed my views on that. I would be glad to repeat them.

Senator FORD. Any other Commissioner want to give this position based on losing on a compromise?

Dr. PARKER. Senator, everybody loses on a compromise.

Senator FORD. Just like a fellow said one time. There are no victories in Washington, just varying degrees of defeat.

I pass, Mr. Chairman.

Dr. PARKER. Senator, if I could answer some of your previous questions as well as the question on whether we had differences of opinion, I think if we had come to this table and said that three people from very different backgrounds had arrived to exactly the same numbers at exactly the same time, you would have felt there was a stacked deck. Of course, that is not the case at all.

We had very different views, different approaches, et cetera. But in order to have a unanimous view we did compromise and none of us gave up any of our principles. But on the numbers and on the timing there were obviously some compromises.

The CHAIRMAN. Let me see if I understand this. In what respects does an MRS differ from this 5,000-ton facility other than the means of financing, which is purely a political judgment, and the size? Could you tell me that, Dr. Parker?

Dr. PARKER. Yes, I will try, Senator Johnston. I think if I could also reply to one of the questions that Senator Ford asked at the same time, the way we arrived at these numbers was to look at the amount of dry pool storage that would be needed at each reactor, and then there was a judgment made as to the number of utilities that would choose to store on-site.

That is a pure judgment call. We do not know that number. And one of the proposals that we made in our report is that that could be determined by an auction system so the utilities would have to commit themselves as to whether or not they wished to do that.

We know that some utilities have said they would like to do that. So there is no way of knowing at the present time, because most utilities, as you can see from our report, are not facing that situation at the moment. Most utilities, we believe or we have been told, have a five-year planning horizon and did not come to that decision point.

There are only two utilities that have at-reactor dry storage at the present time. So the question then on how many times utilities would pay for it then depends upon how it is financed and goes to the heart of the question that Senator Ford asked.

In the early days—and this is something that is very familiar to all of the Senators—reprocessing was expected, so most of the utilities did not build large pools. They expected the fuel to be taken from them very shortly after it was discharged. When the Act was passed, then there was an expectation certainly that the fuel would be picked up in 1998 and therefore again they did not build large pools.

As the utilities became aware that this might not come to pass, they built larger pools or they now are going to on-site dry reactor storage. Those utilities have done that who are able to do that, have had extra costs that they did not anticipate. They feel that they should not then pay for an MRS which they may not use.

So the question certainly could be reversed the other way and take money from the waste fund, which all the utilities have con-

tributed to, and compensate those utilities that have been forced because of the changes in the pickup that they expected, to compensate them for those extra costs. That certainly would accomplish the same thing on the equity, which is what we were concerned about and we discussed among ourselves that as a possibility.

Either way, though, so that the utilities that were forced not by their own purposes to have their ratepayers pay twice, should not be put in that position.

The CHAIRMAN. You understand the present law mandates a fee which is to pay for the repository and the MRS.

Dr. PARKER. Yes.

The CHAIRMAN. So your proposal is to have them pay again. That is paying twice, is it not?

Dr. PARKER. Some utilities have already made that payment, Senator, for on-site storage and will have to make that.

The CHAIRMAN. Well, they did not believe what the government said, so they went ahead and did it themselves. But they have been assessed a fee which covers the MRS and the repository, in theory at least.

Dr. PARKER. That is certainly correct, Senator, so they are paying twice. They paid for the on-site storage and they have paid for the MRS because they have paid into the waste fund. So they have actually paid twice.

Senator MCCLURE. If I could put it another way, they have their own MRS.

Dr. PARKER. You are absolutely right.

The CHAIRMAN. That is just a couple of utilities, is it?

Dr. PARKER. At the present time, but other utilities are already negotiating to do exactly the same thing.

The CHAIRMAN. Back to my question. Would you tell me how this 5,000-ton facility differs from an MRS other than in size and in the means of paying for it?

Dr. PARKER. This is for a limited time as well.

Senator MCCLURE. What period is that?

Dr. PARKER. We would store fuel only for the year 2000, assuming that the repository is in place then to accept that fuel.

The CHAIRMAN. By the year——

Dr. PARKER. 2006.

The CHAIRMAN. 2006 you shut down the 5,000-ton facility?

Dr. PARKER. Obviously only if there is a repository in place to accept that fuel.

The CHAIRMAN. If there is a repository in place, then you shut it down?

Dr. PARKER. You could.

The CHAIRMAN. Well, you could shut down the MRS, too.

Dr. PARKER. Yes, sir.

The CHAIRMAN. What then is the difference, other than size and the means of paying for it?

Dr. PARKER. And the time frame.

The CHAIRMAN. Well, the linkage. You say in effect you ought to de-link the MRS, make it smaller and build it now. Is that right?

Dr. PARKER. That is right.

Mr. RADIN. There is another difference, Senator, and that is the MRS was conceived of as a so-called integral facility in which all the spent fuel would move through the MRS to the repository. This would not necessarily be an integral facility; in other words, fuel could be shipped directly from the utility to the repository. So that is another difference.

And then another difference is that there is no time linkage in this facility with the repository.

The CHAIRMAN. Now when we considered MRS some years ago there was a lot of testimony on this question of cooling down the rods. I hate to keep coming back to it, but there was a lot of testimony on that.

As I recall the times, they wanted to put rods in the pools on site for only a year or two—three years—and then they were going to put it in the MRS for how long was it, a couple of years, as I recall.

But we had these graphs on the heat that was generated which fell off very rapidly so that the number of years that it would stay in the MRS, whatever that figure was, was very critical because to take these hot rods right out of the pools and put them in salt—at that time we had not chosen Yucca Mountain—would melt the salt. In Yucca Mountain, it would crack the tuff or the granite or whatever the host rock is.

Now we have at least tentatively chosen Yucca Mountain, subject to characterization. Is that no longer important?

Dr. PARKER. Senator, you may recall you asked that question earlier and I said I would find the place in the report that we have the answer to that. And it is actually on page one. So if you look on the third full paragraph, the last sentence in the third full paragraph, we say: Other nations also plan to construct geologic repositories, but most nations plan to store spent fuel or waste from reprocessing for many years before eventual disposal.

We think, I personally think—and that is one reason it is in the report—that it is very important so that we do not have these high temperatures.

The CHAIRMAN. Well, you sort of refer to what other nations do, and that is the reason to a large extent we went to MRS, but it has really disappeared from the report as being anything important. Indeed, your facility, your 5,000-ton facility, can be bypassed and go straight to the repository.

Does that not mean that you would have to build a different kind of repository to accommodate greater heat, to have greater distances between your bore holes, some would call them?

Dr. PARKER. The present contract, as you well know, Senator, is oldest fuel/first pickup, and so that means the oldest fuel—the well-aged fuel—would be picked up first. So because of the limitations in the acceptance rate at a repository, whenever it is available——

The CHAIRMAN. Sure. For the time-being we have got some old fuel. But as I recall there is something like 90,000 tons to be generated by present reactors during their life, and only 20,000 tons has been yet so far generated. So you have got 70,000 tons yet to go and if you did a plot of the aging of the fuel rods to be received they would be getting younger all the time.

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I forget at what time they would be so young that they would be quite hot, but it would be fairly soon, certainly in geologic terms and maybe nuclear waste terms or geologic terms. In any event, it seems to me that changes the design of the repository because it has got to accommodate more heat, does it not, if you do not have this integral MRS?

Dr. PARKER. Well, I think they are two separate questions, Senator. The DOE has set a rule: oldest fuel first. And it can set any rule it chooses as to the waste that it will accept. Right now it is no younger than five years can be shipped from the reactor. And if the repository keeps receding further in the future, then for the present generation of reactors that fuel will be very well aged, not in geological terms but certainly in reactor terms, will be very well aged by the time it gets into the repository, because they are talking of a relatively modest acceptance rate at the repository. It cannot all go into the repository in one year even though it is available.

So as long as you take the old fuel first you will still maintain an inventory of aging fuel at the reactors in the spent fuel pool or in this UFIS or MRS or whatever other interim storage facility you build.

The CHAIRMAN. So that you are saying that it does not need further aging beyond going from the pools to the repository?

Dr. PARKER. I hope that is not what I said, Senator. I do believe that one should use aged fuel in the repositories.

The CHAIRMAN. Well, where does it get that aging if not in the pools?

Dr. PARKER. On-site storage or in the UFIS or the MRS.

The CHAIRMAN. Well, you are saying we should not have the MRS.

Dr. PARKER. Well, the UFIS, then, sir.

The CHAIRMAN. But you are saying you can bypass UFIS and go straight to the repository.

Dr. PARKER. But, as I mentioned earlier, there is an administrative rule now by DOE to take oldest fuel first, and they have published the schedule of what they intend the pickup from each of the reactors to be. So that is aged fuel, sir.

The CHAIRMAN. And is there room in the pools for that?

Dr. PARKER. For a majority of it. As we mentioned earlier, if one looks on pages 60 and 61 this gives the example of two cases. We have run many, many more cases. As a matter of fact, we could have filled this room up with computer runs, which we obviously chose not to do, to explore all these different options.

We can provide you with any specific option that you would like.

The CHAIRMAN. Maybe I am not understanding. Let me see if I can state it in another way.

If we built your facility, your UFIS facility, and we had our repository on line by 2010, are you going to be able to accommodate all the fuel with the proper age so that it is not too hot when you put it in the repository?

Dr. PARKER. I think until the exploration of Yucca Mountain is complete, until we understand exactly the properties of that rock and how it responds to the temperature rises, I do not think we can answer that question.

The CHAIRMAN. Well, we used to be able to say that was a consideration. Can you say it is probably not a consideration, it probably is?

Dr. PARKER. No. I think it is absolutely a consideration. I think the exact amount of the consideration I do not think we know at the present time.

The CHAIRMAN. Why is it an important consideration?

Dr. PARKER. Because we know relatively well from many experiences how different geological environments react at very modest temperature increases. When we go to the high temperatures that have been projected in some instances by the Department of Energy, this raises all sorts of scientific questions to which we do not yet have the answers.

The CHAIRMAN. They may be very serious scientific questions?

Dr. PARKER. Well, practically every other nation has chosen to bypass those questions by keeping the temperatures low, sir.

The CHAIRMAN. Well, I understand that Yucca Mountain has not yet been characterized, has yet not been approved, and we also do not know what the tuff would do. But in this long report here there is nothing about cooling waste other than the fact that all these other nations are going to do it.

We go into great detail about the difference in nominal cost and non-nominal cost between linked MRS and non-linked MRS. But one of the biggest considerations we had here was this question of cooling, and it seems to me that as I hear it you are saying no, that your system of 5,000 tons would not provide that necessary cooling but we did not consider that because we do not know what all the properties of tuff are and we do not even know if it is going to be at Yucca Mountain.

Dr. PARKER. I am not sure that is quite what we said. If you look on page three, which is the charge by the Congress to the Commission, it lists at the bottom of that Figure 1.2 items A, B, and C, which deal precisely with the questions that you are asking us right now.

We said that until we knew which site was selected for a repository and we knew better what the characteristics of that were and experiments carried out in situ we could not answer that question. So we have said we have ducked that question. So we recognize that question and we realize it is an important question, but we said that we were not in a position because of the present state of knowledge to answer that question.

Senator MCCLURE. Just this much so that we get some parameters. When a fuel assembly is removed from a reactor and placed in the pool, it is quite hot, and that heat dissipates rapidly over the first few years after it is taken out of the reactor.

If I recall correctly, a spent fuel assembly after a few years—and I have forgotten the exact number of years—the heat energy dissipated from that fuel rod assembly is roughly equivalent to the heat of a 60-watt bulb. But in the first years it is quite a lot hotter than that. As a matter of fact, if you are talking about the geological repository in which you have physical activity going on down there, probably you add more heat to that environment from the lights you use than you do by putting the fuel assembly in it.

But in the first few years that is not true.

Dr. PARKER. I am not sure about the last part, the exact number, Senator, but your concept is absolutely right.

The CHAIRMAN. I mean, it is hot enough to crack the rock or melt the salt.

Senator MCCLURE. In the first few years.

The CHAIRMAN. To put it in layman's terms, in the first few years, is it not?

Dr. PARKER. It depends upon how widely you space it and then how far the cracking would extend. You could, of course, have very high temperatures right near the spent fuel elements and you could space them so widely that the overall temperature would be low. That is certainly possible.

Senator MCCLURE. Another way of illustrating the heat that is there, you have been to the repository in Sweden, as have we.

Dr. PARKER. Yes, sir.

Senator MCCLURE. And those transportation casks that come in to be placed in that repository have fins on the outside of the cask. And you can walk up to that cask and put your hand on it and you can feel that it is warm, but it is not warm enough to hurt your hand. Is that correct?

Dr. PARKER. Yes, sir.

The CHAIRMAN. Do you know what the design criteria of the repository are in terms of the aging of the rods?

Dr. PARKER. I believe that five years is the only thing that is on the design now, sir.

The CHAIRMAN. So all these calculations are proceeding on the basis of five-year rods?

Dr. PARKER. I believe that the new cask requirements that the Department of Energy has asked for are based upon ten-year aged fuel.

The CHAIRMAN. Which is the design criteria?

Dr. PARKER. For the casks is based on ten-year aged fuel.

The CHAIRMAN. But I am talking about the design criteria whereby you calculate the heat in the repository.

Dr. PARKER. Well, the fuel that would be provided to the repository would have to be at least ten years, sir.

The CHAIRMAN. At least ten years. Can you do that without an MRS? Can you age your fuel for ten years?

Dr. PARKER. You could leave it on-site.

The CHAIRMAN. Is there space to do that? You have this calculation about by the year 2006 there will be a need for 9,000 tons of capacity.

Dr. PARKER. Neither we nor the Department of Energy yet have been able to ascertain whether or not there are reactors that will not have space on-site. Our contractor was not willing to guarantee 100 percent that there would be space on-site, though they were not able to identify any specific reactors that would have that difficulty. The Department of Energy has a study under way now that within the next few years will provide that answer.

The CHAIRMAN. Well, you know, to put it in plain terms, the job we have now is, I think, made much more difficult by this report. I mean, it is kind of like the Bible; there is something in here for anybody. You can say well, this proves this, it proves that. But the

main conclusion is you do not like an MRS, but we have got this other thing.

And the other thing—you know, is it just a question of bucks, that it costs a few more dollars to do that? If so, I think you are going to have some Senators who are going to say, look, you want to put it in my State and all it does is it might cost a few more dollars to do that. Why don't you put it in the repository, if that is all that is involved?

I mean, frankly I do not understand what you are saying.

Senator FORD. It is just not going to be done. That is what you are betting on. That is your mortality rate.

The CHAIRMAN. I am not sure I understand the answer about this cooling down of the rods, whether this is an appropriate, useful function of MRS, or whether we know about that, or whether we do not know, or whether it is important. That was one of the driving conclusions that the experts told us about MRS. It is important. We package it, we cool it, and you put it in the repository cooler.

All these European countries are doing that. That is what they told us. They said, you know, the French say if we cool this down and we have got this convection cooling, it gives us time to consider so when we put it finally in a repository it is going to be cooler and less radioactive, easier to deal with.

Now suddenly that has disappeared somewhere. It is in there. You say the Europeans are doing it, but we do not need to do it. But I do not know why we do not need to do it.

Dr. PARKER. Senator, I think you have read more into our report than we have actually stated. I think we have said that we do not believe a linked MRS is useful, not that the functions of an MRS are not useful.

As a matter of fact, we have said quite to the contrary, that the function of an MRS, if it were not linked, are useful, and we detailed them and I read those earlier into the testimony as to what the advantages were.

On the cooling aspect, I certainly believe that it is an extraordinarily important item, but, as we mentioned and as I read to you, because we do not know the exact site, we do not know the specific characteristics of that host rock, we could not do the calculations to show what the benefits would be or not be of that cooling.

The CHAIRMAN. Well, if you assumed it was Nevada, Yucca Mountain—and I think that is a pretty good assumption unless they come up with some pretty strong reasons not to put it there—we do not want to prejudge it, but we have not heard or at least I have not heard any objections yet. But nevertheless, if you assume that can you tell us what the advantages of cooling will be? Can you calculate those?

Dr. PARKER. We certainly could do that, Senator. We have not done any of the design work, of course, for what the waste package would be, nor do I believe the Department of Energy yet has completed those kinds of studies. And until we have that kind of information we certainly could do it in a generic sense, if you would like that, and before our sunset provision comes into effect we could do some of these further studies.

The CHAIRMAN. Well, as I say, the cooling of the rods, packaging, cooling, collection were some of the driving considerations. When

we first passed legislation, it was pure MRS and we did not have a repository. When I say "we passed', when the Senate first passed legislation.

And then in the next Congress we came in with a grand compromise to have a two-track MRS and repository, and we accepted that. We were not convinced that it was necessarily the best way to go. I think it is safe to say there are some of us who really believe that a series of MRSs or at least more than one MRS as opposed to a repository may be the best way to go.

In any event, the law is passed and we have the MRS now. But one of the biggest advantages was the cooling of those rods. And now I think it ought to be discussed. Is it true? Is it valid? Is it important? I hear "extraordinarily important", but we have not done the calculations.

Would it be useful to do those calculations on tuff?

Dr. PARKER. Since we did not examine it, for the reasons I mentioned, we have not looked at how much of those calculations the Department of Energy has already done. We certainly have not done those calculations. We certainly could look at what the Department of Energy has done and also do some of those calculations ourselves.

The CHAIRMAN. Do you think it is likely to be a very important factor?

Dr. PARKER. Senator, I agree with you totally. I think it is an extraordinarily important factor not to have the temperature in the repositories too high.

The CHAIRMAN. And we need an interim storage for that, really, to do it usefully?

Dr. PARKER. We need interim storage someplace to do that, that is correct.

The CHAIRMAN. And we have been proceeding sort of under the assumption that you could not do it on-site. I mean, in some places some have already done it with dry casks, but that is probably more expensive than to do it in a repository, in an MRS, is it not?

Dr. PARKER. I believe it would be, sir.

Senator FORD. Mr. Chairman, let me get back to a point I made earlier. I do not want to throw any aspersions on anyone because I think these gentlemen have the toughest job that I have seen in a long time. I think they are honest and I think they are intelligent. I think they are men of good character.

But they would have helped me more and maybe the Committee more with a two-to-one report—rather than a compromise—that would have said something more definitive. We have gotten ourselves into the compromise of this may do or that may do, if you link this, if you do not link that.

And I would have rather had a majority report and a minority report, as we do, so I could sit down and look at what the objection was, and you had two for and one against or however. But I think it would have been more definitive.

What you have done now is arrived at a compromise and the compromise has gotten us into a position that we do not know what to do. So rather than being definitive you have given us a report here that you all three could agree on. That puts us in a position

that we cannot act by the report we have received. We have to read between the lines and I am not one who likes to do that.

I like to be looked in the eye and say by damn this is the way it is, and if you do not like it, you vote the other way. I may do that. But I sure would like to have your report be more definitive, and I think that is part of my problem, Mr. Chairman.

The CHAIRMAN. Gentlemen, I wonder if you believe it would be helpful to go back and look at the question of cooling and on-site storage. What is the relative ability and cost of on-site storage? Would that be useful to look at, or is that in the report?

Senator MCCLURE. Mr. Chairman, I just wonder, before asking these gentlemen to go do that, they would probably do the same thing first that we might be able to do ourselves, and that is find out if that information is directly available from studies already completed by DOE.

The CHAIRMAN. Well, it may well be, but I think you would need to use the two pieces of information—the on-site storage and cost along with the cooling factor. It might have to be a Kentucky windage kind of judgment.

Senator FORD. Thank you very much.

The CHAIRMAN. Since we do not know for sure what the host rock is and we have not done the characterization so we cannot tell for sure.

Senator MCCLURE. Mr. Chairman, if I might, there is one thing that we ought to state very clearly for the record, one thing that has changed over the last decade, and that is the assumption of how much can be stored at site.

When we passed the Waste Storage Act, we were acting under what was then the best professional advice we could get that indeed we had reactors that would shut down because of their inability to store spent fuel rods. Since that time NRC has approved greatly expanded on-site storage and that approval was, I think it would be fair to say, most of us were very skeptical about whether or not that could be obtained in a timely way. It was obtained; it is being done.

That changes the time frame in which we must react, and that is a dramatic change over the last several years.

We need to have, in addition—and again I assume we can get it from DOE—the current on-site capacity as it would be projected over the next ten or 15 years. I am also one who believes that we perhaps need to stretch our planning horizons just a little, because in spite of the fact of the capability of the Congress to enact legislation with respect to the repository site, the technical work is going slowly and predictably will continue to go slowly, in my view.

The CHAIRMAN. Well, we are going to have to speed that up by some means. We cannot stay at stalemate forever.

Dr. KLEIN. Senator, I would like to comment just briefly on your cooling question. I do not think there is any doubt that cooling the spent fuel will make the disposal easier and will be an important consideration. But you have hit specifically on the difficulty. Since the repository site has not been characterized specifically, until that host rock is examined the magnitude of that effect is what is difficult to determine.

So I do not believe with the current technology that we have and the current information that we would be able as a Commission to definitively answer how much cooling is required for that host rock until that site is characterized. But your assessment is correct in that cooling should make the job easier and is a prudent thing to do.

The CHAIRMAN. Or said another way, heat makes it much more difficult and probably much more expensive. We have to legislate on less than perfect judgment, so what we would like to do is for you to give us, if you can, if you think it would be useful, another bit of information on how important it is likely to be.

I hear "extraordinarily important", I hear "important", "more costly". To what extent can that extraordinarily important factor be accommodated within no-MRS, the 5,000-ton MRS, or 15,000-ton MRS? Because we are not going to know. I mean, by the time we do all the studies, all the characterization, it could be—how much longer will characterization take? Ten years?

I mean, we need to make a decision on MRS before ten years, I think, and so for the purpose of legislating if you could say well, we do not know for sure but we think you need some means to cool down these rods for ten years, the design criteria is ten years, then we ought to figure what is the best way to cool the rods down—water on site, cask on site, or MRS.

I mean, I can tell you we entered into a political judgment—as you point out, it was a political judgment—to have this linkage, but all the linkages were linkages. I mean, the 15,000 tons was also a linkage. So it is not fair to say well, you know, we do not want this to become a de facto repository because it may go up to 36,000 or 38,000 tons We have a linkage in there of 15,000 tons designed to protect that very thing.

What I get from this is—what I think I get from it is—that yes, we need an MRS, but we are sensitive to this political question of linkage, so we are going to reduce the size of it. That, though, does not make our job any easier.

What we would be faced with is the onslaught to say you said we need a Commission; you have got all these experts and now they say you do not need an MRS. And we say well, you know, it will cost more without one, and they say, well, we have spent all this money anyway, so spend a few more bucks and avoid having to put it in our State. We have already got one State, so we do not need two.

I believe it is more complicated than that. I believe that there are advantages to interim storage. I mean, extraordinary advantages. We were led to believe that when we first passed MRS.

Senator MCCLURE. I hesitate to get back into that whole debate, but one of the advantages of an MRS is that human beings, believe it or not, may learn something. It might just be that one year or two years or five years from now we will know something we do not know now. I know the modern-day know-nothings reject that view—that human beings are at the highest level of perfection we will ever attain and we are not going to be able to do anything better, so we have got to do with what we know now.

I reject that view.

The CHAIRMAN. Senator Murkowski has not had a first round.

Senator MURKOWSKI. No. I am quite satisfied with how this is progressing, in one sense.

The CHAIRMAN. You have done extraordinarily difficult work and you have applied yourselves with great energy and great dedication to this job. Would you be willing to go back and supplement the report? Is that useful?

Mr. RADIN. I can only speak for myself. I think our term of office expires on December 31 of this year, and we are prepared to continue to be of service to whatever extent we can for the remainder of this year, Senator Johnston, speaking for myself.

The CHAIRMAN. Is that enough time? Probably not. I mean, I do not want to ask you to do something if you think it is not likely to be productive. It seems to me that it would be.

Dr. PARKER. I think the specific questions that you and Senator McClure and Senator Ford have asked us, I think we could give some answers that would not be as accurate as we might like if we had a longer period of time. We certainly could answer in a general sense.

I think, as Senator McClure has pointed out, the first thing we would have to do is look at what has already been calculated by the Department of Energy. We have not had any testimony from them on those matters because we made the policy decision that there was not sufficient information known for us to come up with a definitive answer on that specific point.

I can only speak for myself, but I do know that I think it is equally true for the other Commissioners, we have postponed a lot of other engagements because of the MRS Commission and most of our calendars are extraordinarily loaded for the next few months. We do not know whether two months is going to be sufficient for us to provide you all of those answers. Plus, we are losing our staff. We have a small, dedicated staff. Some of them have already left, and that also poses a problem for us.

But I think the answer to your question is yes. I speak for myself and I join the Chairman in saying yes, I would be happy to.

The CHAIRMAN. That you can give it a try in the next few months?

Dr. KLEIN. Certainly we now have the analytical tools to do a lot of comparisons and further studies, and I think we could do those cases fairly rapidly. I think the difficulty that we are going to find is on the cooling of the host rock. We will have to see what DOE has done to find out whether we can get you a definitive answer on that.

The CHAIRMAN. It would be a value judgment of your opinion of the importance of that factor to an MRS or a 5,000-ton UFIS or whatever and whether that necessary cooling can be accommodated by 15,000 tons, 5,000 tons, no-thousand tons, the relative importance of that.

Do any of you gentlemen have anything to add before we close the hearing?

[No response]

The CHAIRMAN. Well, thank you very much. We appreciate your testimony.

[Whereupon, at 11:45 a.m., the hearing was adjourned.]

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

MONITORED RETRIEVABLE STORAGE REVIEW COMMISSION

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Executive Director and
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DEC 20 1989

The Honorable J. Bennett Johnston
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, D.C. 20510-6150

Dear Senator Johnston:

Enclosed are the responses of the Monitored Retrievable Storage Review Commission to the questions posed by Members of the Committee in a letter dated November 6, 1989 in followup to our testimony at the November 2, 1989 hearing. In response to questions asked during the hearing, the Commission also is submitting a paper on the need for an MRS for the long-term aging of spent fuel.

Senator McClure requested responses to his questions from each individual Commissioner. However, since the Commissioners have no differing views on the responses to the questions, individual responses are not provided.

If the Committee Members or Committee staff have any questions concerning the material we have submitted, they may contact any of the individual Commissioners.

The Commission will cease to exist on December 31, 1989. Again, we thank you for this opportunity to serve the Congress.

Sincerely,

Alex Radin
Chairman

cc: D. Klein
F. Parker
J. Axelrad

ATTACHMENT 1

QUESTION 1. You have stated that "There are a number of advantages that would justify a central storage facility not limited in capacity nor linked to the repository schedule and operation." Why then did you not either recommend such a facility or recommend that the current linkage between an MRS and a permanent geologic repository be repealed? Was this a political or technical decision on your part?

RESPONSE:

The advantages attributed by the Commission to an unlinked MRS were contingent upon four important factors: (1) having an MRS available early; (2) a significant delay in the repository program; (3) no linkages in time between the MRS and the repository, and (4) no capacity limit on the MRS. Each of these factors is clouded at this time by a great deal of uncertainty.

For example, even if a decision were made today to have an MRS, the date when an MRS would be available is by no means certain. Legislation would have to be enacted to remove the linkages to the repository schedule, and it is uncertain how quickly Congress might complete such action. Assuming, however, that Congress approved the removal of the time linkages, an MRS might then be delayed because of difficulties in site selection, licensing or construction.

Because of uncertainties about the date an MRS is likely to be available and the long planning horizons of the utilities, many utilities would be forced to provide expanded on-site storage of spent fuel in any event. (See Table 8.1 of the Commission's Report, p. 88.)

With regard to the date of opening of the repository, the Commission found in its studies that if the repository were delayed beyond the year 2013, the need for an MRS would be greater because of the sharp increase in the

number of nuclear power plants whose current licenses will expire.[1] The economics of an MRS would become more favorable then because of the added costs of storing spent fuel at the sites of shutdown reactors ready to be decommissioned. Subsequent to the completion of the Commission's report, DOE announced a delay in the opening of the repository until 2010. However, it is uncertain whether even this date will be met. Uncertainty in the date of repository availability was one of the reasons the Commission recommended Congress revisit the need for interim storage in the year 2000.

Doubt about the date when the repository would be available also creates uncertainties in the capacity needed for an MRS. Our computer simulations showed that if the repository were to be delayed until 2013, the inventory at an MRS would be as high as 36,000 MTU in 2013.[2] If the repository were to be delayed until 2023, the inventory at an MRS would be as high as 66,000 MTU in 2023.[3] An MRS having an inventory this large could raise serious concerns about the MRS becoming, or having become, a de facto repository which could detract from the primary goal of the Nation's nuclear waste management system:

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[1] The Commission recognized that some reactors may obtain license extensions while others may shut down before their licenses expire. It is impossible at this point in time to predict how many will fall in either category. It therefore seemed reasonable to assume for purposes of our analysis that the early shutdowns and the life extensions would offset each other and we assumed an average 40 year life for all reactors.

[2] These numbers were derived using the Commission's WACUM simulation model. The model assumed the MRS would begin operations in the year 2000 and that the MRS and the repository would take fuel at the DOE designated acceptance rates. The amount of spent fuel at the MRS would continue to rise until the rate at which fuel was being discharged from the reactors fell below the rate at which fuel was being accepted by the repository. The inventory at the MRS would peak at just over 56,000 MTU by the year 2020.

[3] The inventory at the MRS would continue to rise and would peak at just over 72,000 MTU in the year 2028.

the building of a permanent geologic repository as expeditiously as possible, consistent with meeting necessary safety and other public interest considerations.

Because the realization of all of the advantages of an unlinked MRS was based upon factors that were so time dependent, the Commission did not believe it was necessary or desirable to make a commitment to an unlinked MRS at this time. The Commission focussed on the most urgent needs to be served by an MRS and recommended facilities to provide those needs. The Commission also recommended that Congress reexamine the need for an MRS in the year 2000 when more is likely to be known about several of the factors that affect the need for interim storage.

As the report indicated, the Commission, in response to its mandate to "evaluate the utility of an MRS facility from a technical perspective," found that there is no technical basis for the linkages. However, the Commission did not construe its mandate from the Congress to limit its recommendations to technical considerations. One of the charges by the Congress to the Commission was to "obtain comment and available data on monitored retrievable storage from affected parties, including States containing potentially acceptable sites." The views expressed included both technical and policy considerations and the Commission felt obliged to take both categories of views into account. The Commission's recommendations therefore reflect both technical and policy considerations.

QUESTION 2. You acknowledge that the conclusions you reached do not provide all the benefits that an MRS would have provided, especially with regard to an integrated nuclear waste system from the point of the waste's generation until its ultimate permanent disposal. Why then did you recommend a combination of public and private facilities that provide fewer benefits than would be provided by an MRS?

RESPONSE:

For the reasons stated in the report (Conclusion 3, p. 100), the MRS Review Commission could have recommended at this time an unlinked MRS. However, such a recommendation would entail premature commitment of resources. In contrast, our recommendations would meet the storage needs as seen at present, and would leave the sytem open to changes as they occur. In the next ten years, more will be known about the suitability of the Yucca Mountain site, the availability of dual-purpose casks, and the advantages and disadvantages of rod consolidation. Congress will be in a position to make a more informed decision in the year 2000 about the need for interim storage. (See response to Question 9 for discussion of the comparative costs of interim storage options.)

QUESTION 3. If the three conditions stated in your letter of transmittal are met, if these conditions were satisfied, would you then recommend an MRS?

RESPONSE:

It is impossible to determine whether the Commission would support an MRS if the three conditions were met. The conditions are subject to so much uncertainty, as indicated in the response to Question No. 1, that the Commission did not have discussions as to what its recommendations would be if the three condjtions were met. Even if the three conditions were met, a decision on the need for an MRS would be made based upon what other options were available at the time (e.g., dual-purpose casks).

Faced with the many uncertainties that could affect its decision, the Commission felt that the most prudent course was to recommend more limited facilities to address the most urgent needs for spent fuel storage. At the same time, the Commission recommended a reexamination of the issue in the year 2000, when some of the uncertainties might be resolved and additional storage options might be available. Mid-course corrections are normal and highly desirable in comparison to setting a fixed course at this time for 40 to 50 years.

QUESTION 4. If the Negotiator in the NWPA were able to find a willing party and undertake negotiations for an MRS as envisioned in the NWPA, would you support its construction?

RESPONSE:

In its report, the Commission rejected an MRS linked as envisioned in the NWPAA and would not support its construction even if it were sited by a negotiator. The Commission believes it would be useful for a negotiator to assist in site selection for the Federal Emergency Storage and User Funded Interim Storage facilities recommended by the Commission. Decisions about expanding the capacity of those facilities should be left until Congress revisits the need for interim storage in the year 2000. It would be a premature commitment of resources to recommend an unlinked MRS at this time even if one were to be sited by the Negotiator.

QUESTION 5. What capability does the Commission see for expansion of the on-site storage capability at existing nuclear power plants?

RESPONSE:

The Commission believes there is quite a large capability to expand the on-site storage capacity at existing nuclear power plants. Our contractor studies and preliminary findings from the Department of Energy's Facility Interface Capability Assessment (FICA) study show that most, if not all utilities, have already reracked with high-density racks to increase the amount of in-pool storage. In addition, the referenced studies show that most, if not all, utilities could expand on-site storage using dry storage technologies already in use at some sites. If further developments in dual-purpose casks and rod consolidation take place, this could increase the utilities' options for on-site storage. The NRC has said that spent fuel can be safely stored on-site for up to 100 years.

To be sure, a few utilities, for technical reasons, may be unable to expand their on-site storage facilities and others may encounter public opposition to expansion of on-site storage. The User Funded Interim Storage facility recommended by the Commission should provide capacity for those utilities that cannot provide on-site storage until Congress revisits the issue in the year 2000.

QUESTION 6. You recommend that the need for an MRS should be reexamined in the year 2000. Reference is made to the uncertainty in the date for operation of a permanent repository. If this date is your principal concern, why not immediately reexamine the date, rather than delay as you suggest. Would you comment?

RESPONSE:

The Commission did not feel that it had either the mandate or the capability to examine the date when the repository might become operational. As indicated in our Recommendation No. 3, we would need further information about the status of the repository which can only be forthcoming when additional surface and at-depth studies are made at the repository site. However, the Commission did do sensitivity studies to determine the effects of repository delay. Furthermore, past events have shown that even with the best of intentions, unforeseen events can cause schedule slippages.

In any event, the uncertainty in the date of operation of a permanent repository was only one of the uncertainties that affects the decision whether to have an MRS. On the other side of the equation, as Question 5 recognizes, is the availability of alternative means of storing spent fuel until the repository becomes available. If spent fuel could be stored at reactor sites safely and at a lower total system cost than at an MRS, then there would be little justification for the facility on the basis of safety and cost. By the year 2000, Congress will be in a better position to judge how much of a delay is likely in the repository program, and the availability of alternative means of storing spent fuel. At that time, a more informed decision on the need for interim storage can be made.

QUESTION 7. What is the basis for the capacity limits that you recommend for the Federal Emergency Storage (FES) and the User-Funded Interim Storage (UFIS) facilities?

RESPONSE:

The basis for the capacity limits for the FES and the UFIS facilities is described in Appendix I to our report. A copy of the pertinent section is attached.

Appendix I

The Commission's Recommendations: Cost, Capacity, and Financing

Section One: Costs

The Commission's recommendations to create the Federal Emergency Storage (FES) and User-Funded Interim Storage (UFIS) facilities do not rest on the expectation that they would reduce the cost of the spent fuel management and disposal system. The FES is intended to provide resilience to the system by insuring that spent fuel can be removed expeditiously from a reactor pool in an emergency and to provide storage for reactors that would have to shut down because they were unable to build at-reactor dry storage facilities. The UFIS will provide an alternative to on-site dry storage for utilities that choose to use it, at their own expense. The UFIS may reduce the share of the total cost that comes from the Nuclear Waste Fund, but it is unlikely to reduce overall system cost.

The annual Federal Interim Storage Fee Study[1] estimates the cost of storage facilities for a number of alternative types, sizes, and locations. In the 1988 report, the capital costs for a 1,900 MTU facility ranged from a low of $140 million for a facility located at a site where transfer facilities and hot cell facilities were already in existence and made use of a field drywell storage system to a high of $220 million for a facility located at a site without transfer or hot cell facilities using dry cask storage.

The Commission also asked Golder Associates Inc., who developed the cost data base and simulation model described in Chapter Six, to provide some preliminary cost estimates. These estimates were based on the encoded cost data base described in Chapter Six, which explicitly incorporates uncertainty about the future escalation of such costs. Thus, they are higher than today's engineering estimates of what it would cost to build and operate such facilities. As emphasized in their report, these estimates were "very preliminary, order of magnitude only."[2] Golder estimated that the capital cost of a 2,000 MTU capacity facility built at a site with existing hot cell and transfer facilities using dry casks for storage would be $330 million. The capital cost of the same facility built at a site without these facilities was estimated to be $370 million.

For a 5,000 MTU facility using dry cask storage, Golder estimated the capital cost to be $530 million if built at a site with transfer facilities and hot cells and $570 million if built at a site without such facilities.

Section Two: Capacity

The recommended capacities of the FES and UFIS are not intended to provide for all storage needs over the life cycle of the national spent fuel management system. The Commission's objective is to provide a prudent degree of resiliency and redundancy in the system over the next 10 to 15 years. The recommendations assume that, as outlined in Recommendation No. 3 in Chapter Nine, the Congress will reconsider the subject of interim storage by the year 2000; the recommendations also reflect the concerns that have been expressed about such facilities becoming a de facto repository.

The FES facility's principal purpose is to provide a place for spent fuel should there be an emergency at a reactor, which would make it desirable to remove all of the fuel stored in the pool. As indicated in Chapter Nine, about 1,000 MTU of capacity would be required to empty a large, full pool at an operating reactor and would always be reserved for that purpose. The remaining 1,000 MTU of capacity would be available for use by utilities that would have to shut down before the end of their designed operating life because they were unable to provide on-site dry storage if the UFIS were not available.

Until the Facility Interface Capability Assessment (FICA) survey being conducted by DOE on reactor capabilities is completed, it will not be possible to ascertain how many, if any, reactors will be unable to accommodate

at their sites all of the spent fuel they will discharge. However, if neither a repository nor an MRS were available, in 20 years about 13,900 MTU of dry storage capacity would be needed at reactor sites. Assuming that utilities plan at least five years ahead, provision has already been made for about 1,300 MTU of dry storage. Thus, even if as many as 10 percent of the reactors were to find it impossible to store additional discharges of spent fuel on-site, the provision of 1,000 MTU of capacity for this purpose seems reasonable and conservative over the 10- to 15-year planning horizon the Commission has used.

Reserving 1,000 MTU for emergency purposes also appears to be a reasonable and conservative assumption. Emergencies at nuclear power plants that would require the reactor to shut down or a pool to be emptied are rare events. The frequency of rare events is difficult to predict. However, some calculations that provide rough estimates are available. The *Reactor Safety Study*, commonly referred to as WASH-1400 or the Rasmussen Report, which was published by the NRC in 1975, estimated that the probability of a serious accident involving a core meltdown, in the current generation of reactors, was 1/20,000 per reactor year.[3] Assuming 100 reactors will be operating over the next 20 years, there would be 2,000 reactor years. Using the WASH-1400 probability estimate of a core meltdown as the probability of a serious accident would mean that the probability of a serious accident occurring during that time period would be equal to 2,000 x 1/20,000 or 10 percent.

The risk estimates in WASH-1400 have been criticized from a number of perspectives.[4] The Lewis Report[5] concluded that the estimates may be off by one order of magnitude in either direction, which would mean that over the time period in question, the probability of a serious accident would range from a low of 1 percent to a high of 100 percent. In any event, the Commission believes the probability that a serious accident may occur is not negligible, thus, it would be prudent to maintain a capability to deal expeditiously with the possible need to remove the spent fuel from the pool. A reasonable estimate of the capacity required to accomplish this appears to be 1,000 MTU.

Section Three: Financing

In its submission to the Congress of the MRS Program Plan, DOE presented a funding plan calling for the MRS to be financed through the Nuclear Waste Fund. It said it did not consider user funding for an MRS because:

> [A]n approach that imposes a surcharge on only the generators and owners of spent fuel that passes through the MRS facility would be inconsistent with the integral nature of the MRS facility. The decision of which fuel will pass through the MRS facility rests on overall system considerations and not on the preferences of individual utilities. Hence, this approach is not considered further.[6]

As DOE's proposed MRS has evolved from a comprehensive packaging, consolidation, storage, and logistical facility into a simpler "basic" facility providing only storage and logistics, the logic has become less persuasive, particularly if the facility is constrained by an inventory limit.

As explained in Chapter Seven, the smaller the MRS, the more limited its services, and the fewer the number of utilities that make use of it, the weaker the case for general, industry-wide financing on both equity and economic efficiency grounds. Thus, the Commission recommends that its UFIS, a 5,000 MTU, optional, off-line, centralized interim storage facility, be user funded.

There are two basic ways to design user-fee systems: a cost approach and an auction approach.

The *cost approach* is illustrated in considerable detail in the annual Federal Interim Storage Fee studies, which have been prepared by E.R. Johnson Associates, Inc., for the Department of Energy since 1983.[7]

The cost approach is normally utilized when the demand for the facility is expected to be smaller than its potential capacity. In the case of an FIS, E.R. Johnson Associates has identified 13 utility sites as prospective FIS users. By 1995, they estimate, these sites will have a combined demand of only 1,286 MTU compared to an authorized FIS capacity of 1,900 MTU. Since none of the sites has applied to use the FIS and the report assumes an MRS will open in 1998 followed by a repository in 2003, the expectation that the demand for an FIS would be less than its authorized 1,900 MTU limit appears quite conservative. If the demand for the facility were expected to exceed its capacity, a lottery or some sort of "needs" criteria for making an administrative determination would have to be used to decide who would get the available capacity and who would not.

The *auction system* is the second approach to designing a user-fee system. It is best suited to a situation in which the demand for the

facility is uncertain or is expected to be greater than the capacity of the facility. If there is more storage needed than the facility is able or permitted to provide, letting potential users bid for it helps insure that the use will go to those who "need" or value it most (in the sense that they are willing to pay the highest price to acquire it).

Similarly, if it is not clear that there are enough interested users to justify building a facility, holding an auction provides a mechanism for ascertaining how much storage is desired and whether potential users are willing to pay enough to enable the government to provide the service. If the proceeds from the auction were not sufficient to cover the cost of building the facility, it simply would not be built. Subsequent auctions could be held, however, to ascertain if conditions or expectations had changed sufficiently to warrant building the facility.

The design criterion underlying the *cost approach* is to insure that the fees cover all capital and operating costs of the facility. This is done with a two-fee system. As outlined in the annual FIS report prepared by E.R. Johnson Associates, an "initial" fee, paid when the contract is signed, covers all construction and licensing expenses expected to be incurred before the facility opens. Then a "final" fee is determined which covers: (1) transportation costs to the FIS, (2) estimated operating and decommissioning costs, and (3) an adjustment for any over or under estimates that may have been made in establishing the "initial" fee. The final fee is paid when the fuel is delivered to the FIS. Since the report assumes a repository will be available in 2003 and the fuel from the FIS will have to be transferred within three years as specified by the NWPA, there is little (assumed) uncertainty about how long the spent fuel will be stored at the facility. In the case of a UFIS, there might be considerably more uncertainty and, thus, it would probably be prudent to make the operating expenses an annual fee, payable as long as the fuel remained at the facility, rather than part of a "final" fee.

Under the *auction approach*, an auction would be held at which prospective users would bid for the available storage capacity with the highest bidders winning the right to store spent fuel at the facility. In order to assure that the fees collected cover all costs of the facility, a variation of the two-fee system described in the cost approach above could be used. The initial fee would be set on the basis of bids received at auction and paid when construction was initiated. The final fee and annual operating charge would be set as described above so as to insure all costs were fully compensated.

The principal problem in implementing this approach is the uncertainty as to the cost of licensing the facility. The financial risk associated with a commitment to license an inherently controversial nuclear facility of this sort may be too great to permit a two-fee, auction-implemented, user-funded mechanism to function. Further, potential users would need some assurance that a centralized facility would be available by a specific date, if they are to be able to efficiently compare the centralized storage alternative with at-reactor storage. Therefore, prior to the auction of storage rights, DOE, with the advice and assistance of NRC, should provide a realistic estimate of the licensing costs and a guarantee that licensing costs in excess of this amount would be paid for from contingency funds.

Under a *cost system*, eligibility criteria would probably be needed to insure: (1) the demand for storage could be anticipated with enough certainty to make a reasonable estimate of costs, and (2) the demand for the facility would not exceed the desired capacity limit.

If the *auction system* were used, it would be important to make the auction as competitive as possible. Effective competition usually requires a large enough number of bidders to make collusion among them difficult to arrange or enforce. In the case of utilities, the number of potential bidders is probably large enough, at least for storage in the late 1990's and beyond.[8] Under either a cost or an auction system, efficiency would be enhanced if the rights (or contracts) to store spent fuel could be bought and sold. This would allow all utilities to compare the cost of on-site storage options with the cost of centralized storage and make adjustments if warranted. It would also encourage utilities to bid in an auction system since they could sell rights at a later date if their need for storage were to change or if an increase in the price of the rights were to make it more advantageous to sell rather than use them.

Appendix I Notes

1. E.R. Johnson Associates, Inc., for Pacific Northwest Laboratory, "1988 Federal Interim Storage Fee Study: A Technical and Economic Analysis," PNL-6727/UC-85, November 1988 (Hereafter cited as FIS Study/PNL-6727), p. 4–4. Costs rounded in text.

2. Golder Associates Inc., "Interim Storage Facility Cost Estimates," October 2, 1989. Costs rounded in text.

3. Nuclear Regulatory Commission, "The Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," (Rasmussen Report) WASH-1400, NUREG-75/014, October 1975.

4. See Nuclear Energy Policy Study Group, *Nuclear Power Issues and Choices*, Cambridge, Massachusetts: Ballinger Publishing Company, 1977, pp. 221–233, and Wood, William C., *Nuclear Safety Risks and Regulation*, Washington, D.C.: American Enterprise Institute, 1983, pp. 41-43, for a discussion of the WASH-1400 estimates.

5. H.W. Lewis et al., "Risk Assessment Review Group: Report to the U.S. Nuclear Regulatory Commission," NUREG/CR-0400, September 1978.

6. Department of Energy, "Monitored Retrievable Storage Submission to Congress," DOE/RW-0035/1, Rev. 1, March 1987, Vol. III, pp. 5.1-5.3.

7. FIS Study, PNL-6727, November 1988, and previous years.

8. The number of sites projected to require dry storage if an MRS or a repository is not available increases from 12 in 1995, to 32 in 2000, to 44 in 2005.

QUESTION 8. How long do you think it would take to bring into operation either the FES or the UFIS facilities you recommend? If these schedules cannot be met, what would you propose?

RESPONSE:

Once authorizing legislation was passed, the Commission estimates it would take between two to five years to bring the FES facility into operation. This estimate is based upon the Department of Energy's estimates for bringing a Federal Interim Storage (FIS) facility into operation. These estimates are contained in its annual "Implementation Plan for Deployment of Federal Interim Storage Facilities for Commercial Spent Fuel," DOE/RW-0218, January 1989. As Chapter Nine of our report indicates, the proposed FES is similar in size to the FIS facility currently authorized under the Nuclear Waste Policy Act and the Commission recommended that the siting and licensing provisions currently in that act apply to the proposed FES as well. Therefore, the schedule estimates for the FES should be similar.

DOE estimates the time to site, license and construct an MRS to be about 8 to 10 years. It is the Commission's hope that it would be easier to site and license the UFIS than an MRS because it would be smaller in capacity and user funded and may, therefore, generate less opposition.

If these schedules for the FES and UFIS cannot be met, then spent fuel can continue to be safely stored at reactor sites although there may be some sites where out of pool storage will not be possible. If the smaller, more limited FES and UFIS facilities cannot be built expeditiously, it is likely an unlinked MRS would encounter substantially greater delays.

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QUESTION 9. a. Would you provide for the record a comparative economic analysis of the costs of No-MRS, No-MRS but your proposal, an MRS on the schedule envisioned by the NWPA (without delay of the repository), and an MRS on a realistic schedule (but tied to the repository)?

RESPONSE: Tables 1a and 1b contain estimates of the total-system life-cycle costs for ten cases:

-- two cases that do not include an MRS, one with the repository opening in 2003 and a second with the repository opening in 2013 (I-A and IIA);

-- two cases with an MRS linked to the repository as specified in NWPA with the repository starting in 2003 (case I-B, which approximates the schedule envisioned by the NWPA) and 2013 (case II-B, which represents a more realistic schedule);

-- a case with a User-Funded Interim Storage Facility (UFIS) without an inventory cap (but the same, 750 MTU/year acceptance rate used in the previous cases) opening in the year 2000 and the repository opening in the year 2013 (II-E); and,

-- four cases with a UFIS with a 5,000 MTU inventory cap, two beginning operation in 1998 and 2000 with the repository opening in 2003 (I-C and I-D), and two beginning operation in 1998 and 2000 with the repository opening in 2013 (II-C

and II-D);[4]

-- a case with an MRS opening in the year 2000 without an inventory cap and the repository opening in the year 2013 (II-F).

Table 1a shows the estimates in constant 1989 dollars (or in nominal values) and Table 1b shows the same estimates in constant 1989 dollars discounted at an annual rate of four per cent (or in present values).

Comparing the cases in which the repository is assumed to open in 2003 shows:

-- Using nominal values or undiscounted dollars, the No-MRS system is $2.1 billion less expensive than the MRS system and the two UFIS cases are $1.6 billion less expensive than the MRS system.

-- If present values or discounted dollars are used, the No-MRS system is $0.9 billion less expensive than the MRS system

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[4] The cost estimates do not include the cost of the Federal Emergency Storage (FES) facility recommended by the Commission. The capital cost of this facility is estimated to be about $250 million with a licensing cost of about $50 million if it were built as a separate, stand-alone facility. If it were co-located with a UFIS, the incremental capital cost is estimated to be about $100 million with no additional licensing cost being incurred. The operating costs were estimated to be about $25 million per year for a stand-alone FES and about $15 million per year for a co-located facility. Since the FES is intended to provide storage in the event of an emergency and emergencies, by definition, are impossible to predict, no attempt was made to integrate the costs of the FES into the cases reported in the table. If it is assumed that the FES would be co-located with the UFIS, the relative magnitudes are such that the results would not be affected significantly. These estimates are based on an analysis of the costs of these facilities that was prepared after the Commission's report was published and are slightly lower than those presented in Appendix I of the Commission's report. For further information on this point, see response to Question 9b.

and the two UFIS systems are $0.7 billion less expensive than the MRS.

Comparing cases in which the opening of the repository is delayed until 2013:

-- The No-MRS system is $1.3 billion less than the linked MRS system but only $0.1 billion less than the unlinked MRS system measured in nominal values.

-- If present values are used, as in Table 1b, both the linked and unlinked MRS systems are $0.5 billion more expensive than the No-MRS system.

-- The two UFIS cases, which are subject to a 5,000 MTU inventory cap, are about $0.9 billion less expensive than the linked MRS, but about $0.3 billion more expensive than the unlinked MRS, measured in nominal values.

-- In present value terms, however, the capped UFIS systems are $0.2 billion cheaper than both the linked and unlinked MRS systems.

The UFIS proposal was made in the context of a recommendation for a Congressional reevaluation of the need for an interim storage alternative in the year 2000. If it were determined that the repository were to be delayed, one option would be to lift the inventory cap on the UFIS. This case is shown in case II-E, which assumes that the repository would open in 2013 and that the UFIS would continue to accept spent fuel at the same 750 MTU annual acceptance rate used in the previous UFIS cases.

-- This case has considerably lower costs than the No-MRS case ($0.7 billion), either the linked MRS ($2.0 billion) or unlinked MRS systems ($0.8 billion), and either of the UFIS cases, measured in nominal values.

-- In present value terms it has the same estimated cost as the No-MRS system, $9.2 billion, and is less expensive than any of the other cases.

The last two columns in Table 1a relate the cases to the "need" for dry storage.[5] The first (column 7) shows the magnitude of the inventory, measured in metric tons of uranium, at the interim storage facility when the repository opens. The next column expresses that magnitude as a percentage of the total dry storage need that would exist without any interim storage facilities. To illustrate:

-- A linked MRS opening in the year 2000, when the repository opened in 2003, would have an inventory of 4,400 MTU which amounts to 72 per cent of the estimated 6,100 MTU which would have to be put into dry storage if no interim storage facility or repository were available by that date.

-- In the 2013 case, because the date at which an MRS can accept spent fuel would be delayed on a day-for-day, month-for-month basis if the repository were delayed, the linked

[5] The "need" for dry storage refers to the total amount of spent fuel which the WACUM simulation model shows could not be accommodated in pools even if all pools were fully reracked. Some utilities have testified before the Commission that they plan to provide dry storage at the reactor sites and other utilities may make the same choice.

MRS would not be able to accept fuel until the year 2010. As a consequence it would not be able to accept as much spent fuel as any of the UFIS systems.

-- The UFIS without an inventory cap would be able to accept more than twice as much fuel as the linked MRS and would be $2.0 billion less expensive.

-- If the Congress were to remove the linkages and an unlinked MRS were to open in 2000, it would have an inventory of 36,100 MTU in the year 2013, which is twice as large as the estimated need for dry storage. (This assumes DOE accepts spent fuel at the MRS at the currently predicted rate of 3,000 MTU per year after a short ramp up period. Fuel would be unloaded from the spent fuel pools since the MRS would be available to the utilities at no additional cost because it would be Waste Fund financed.)

-- The UFIS shown in II-E would be able to meet 54 percent of the need for dry storage and only have an inventory of 9,750 in 2013.

When considering the costs of a system without an MRS, or the costs of any system which because of linkages or inventory caps may not be able to accept spent fuel, it is important to recognize that the costs included in the estimates of total-system life-cycle costs shown in the tables do not include estimates of the costs that would be incurred if otherwise satisfactorily operating reactors were to have to shut down because they could not store spent fuel at the reactor sites or could not obtain the license

amendments necessary to do so in a timely fashion. The cost of acquiring replacement power for a 1000 MWe nuclear reactor assumed to operate at a 65 percent capacity factor is currently about $300,000 per day or about $110 million per year.

A final relevant attribute of the cost comparisons involves the "voluntary" nature of the costs under user-funding and the mandatory nature of the costs if the facilities are paid for from the Nuclear Waste Fund. Under a user-funded system, the decision to use the UFIS rather than to store spent fuel at the reactor is made by the utility. Therefore, if the utility chooses to use the UFIS, it either expects the cost of using the UFIS to be less than on-site storage or it expects the additional benefits it will derive from the UFIS to outweigh the additional costs.

QUESTION 9.b. Would you provide an analysis of the full costs of your no-MRS recommendation?

RESPONSE:

The costs of our recommendations were provided in response to Question 9a. The methods used to estimate the costs of the MRS and No-MRS cases, and the Commission's recommendations, are shown in Tables 1a and 1b and are described in Chapter Six and Appendix I of our report. Briefly, a panel of experts with experience in the estimation of the costs of spent fuel management and disposal systems met as a group and developed probability distributions for a comprehensive set of cost accounts corresponding to various functions to be performed by the spent fuel management and disposal system. The cost accounts were then integrated into a simulation model which was used to estimate costs under different assumptions as to the start date for the repository and the schedules, nature, and location of the other components of the system. Some differences in the definition and measurement of costs between our estimates and those made by the Department of Energy exist and are discussed in the report, but, in general, the pattern of cost differences between MRS and No-MRS alternatives is consistent, or reconcilable, between the two sets of cost estimates.

The estimates of the costs of the UFIS and FES facilities were made by modifying the cost accounts used to make the estimates of the MRS systems so that they could be used to estimate the costs of the considerably smaller UFIS/FES facilities. Each individual cost account was subdivided in a manner consistent with the basic engineering and technological requirements of the component in question. Thus, for example, the components of the MRS facility

designed according to DOE specifications, which has an annual acceptance rate of 3,000 MTU per year, were scaled down to correspond to the annual acceptance rate of 750 MTU per year used for the UFIS. The receiving and handling facilities at an MRS designed to take 3,000 MTU annually include four, 750 MTU hot cells, for example, while the receiving facilities at the UFIS include one 750 MTU hot cell. A new cost data base was created with cost accounts scaled down in this manner for each relevant account.

When looking at costs twenty years into the future, one also must be cautious about the uncertainties in the predictions. The cost estimates are based on assumptions that may or may not prove to be accurate over the long time period for which the predictions are made, although the relative differences should remain the same unless components of cost for each do not change in a parallel fashion.

TABLE 1a - TOTAL-SYSTEM LIFE-CYCLE COSTS[1] FOR SELECTED CASES AND REPOSITORY START DATES
(Billions of constant 1989 dollars)

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	At-Reactor	O&C[2]	Interim Storage Facility	Transportation	Repository	Total[3]	Inventory When Repository Opens (MTU)	% of Dry Storage Needs Met When Repository Opens
I. Repository in 2003								
A. No-MRS	2.3	9.0	NA	3.7	9.7	24.8	0	0
B. MRS (NWPAA) 2000	1.2	9.8	2.5	3.7	9.7	26.9	4,400	72
C. UFIS (750/yr/5K cap) 1998	1.6	9.3	0.9	3.8	9.7	25.3	3,750	61
D. UFIS (750/yr/5K cap) 2000	1.7	9.3	0.9	3.7	9.7	25.3	2,250	37
II. Repository in 2013								
A. No-MRS	5.1	9.0	NA	3.3	9.2	26.6	0	0
B. MRS (NWPAA) 2010	3.7	9.7	2.1	3.3	9.2	27.9	4,400	24
C. UFIS (750/yr/5K cap) 1998	4.3	9.3	0.9	3.3	9.2	27.0	5,000	28
D. UFIS (750/yr/5K cap) 2000	4.3	9.3	0.9	3.3	9.2	27.0	5,000	28
E. UFIS (750/yr/no cap) 2000	2.8	9.3	1.3	3.3	9.2	25.9	9,750	54
F. MRS (3000/yr/no cap) 2000	1.1	9.8	3.2	3.3	9.2	26.7	36,100	200[4]

TABLE 1b - TOTAL-SYSTEM LIFE-CYCLE COSTS[1] FOR SELECTED CASES AND REPOSITORY START DATES

(Billions of constant 1989 dollars, discounted at 4%)

Column	(1) At-Reactor	(2) DOE[2]	(3) Interim Storage Facility	(4) Transportation	(5) Repository	(6) Total[3]
I. Repository in 2003						
A. No-MRS	1.0	5.3	NA	1.0	3.2	11.6
B. MRS (NWPAA) 2009	0.6	6.6	0.9	1.1	3.2	12.5
C. UFIS (750/yr/5K cap) 1998	0.7	6.4	0.4	1.1	3.2	
D. UFIS (750/yr/5K cap) 2000	0.7	6.4	0.3	1.1	3.2	
II. Repository in 2013						
A. No-MRS	1.8	4.8	NA	0.6	2.0	9.2
B. MRS (NWPAA) 2010	1.5	5.0	0.6	0.6	2.0	9.7
C. UFIS (750/yr/5K cap) 1998	1.5	4.9	0.4	0.7	2.0	9.5
D. UFIS (750/yr/5K cap) 2000	1.5	4.9	0.3	0.7	2.0	9.5
E. UFIS (750/yr/no cap) 2000	1.1	4.9	0.5	0.7	2.0	9.2
F. MRS (3000/yr/no cap) 2000	0.6	5.1	1.2	0.6	2.0	9.7

NOTES

1. Total-system life-cycle costs include all the costs of the system (research, development, licensing, construction, operating and administration) over the entire duration of the development and operation of the system. The cost categories used, in general, follow those used by the Department of Energy in its annual Total-system Life-cycle Cost reports and in the MRS System Studies. The two principal differences between the cost definitions used in the Commission's report and those reported by DOE are: 1) the Commission includes the additional costs incurred for management and security at shutdown reactors as a part of at-reactor costs and DOE does not, and 2) the Commission keeps development and evaluation (D&E) costs constant at the levels estimated for 2003 scenarios in which the repository is delayed while DOE continues to escalate D&E costs. See the Commission's Report, Chapter Six and Appendix I for further discussion of the cost concepts in the tables.

2. D&E stands for development and evaluation.

3. Components may not add to total because of rounding.

4. The acceptance schedules, which indicate how much spent fuel will be shipped to an MRS or repository, that were used in the MRS cases shown in the table are the same as those used by DOE in its studies. In the unlimited MRS case, the amount of spent fuel that would be stored at the MRS, according to DOE acceptance schedules, is twice as large as the amount of dry storage at reactor sites that would be necessary if neither a repository nor any interim storage were available, i.e., they unload the spent fuel pools since the MRS is available to the utilities at no additional cost (it is Waste Fund financed).

QUESTION 10. You recommend that the issue of interim storage should be reexamined in the year 2000. What should be the basis for that reexamination? Are you recommending that the capacity limit or the need for interim storage should be reexamined?

RESPONSE:

The factors which would provide the basis for that reexamination, as described in Chapter 9, are:

a. Status of the repository;

b. Status of nuclear power plants, i.e., number that shut down early, license extensions, utilization of extended burnup, etc.;

c. Availability of at-reactor storage;

d. Utilization and adequacy of the 2,000 MTU Federal Emergency Storage facility;

e. Utilization and adequacy of the 5,000 MTU User-Funded Interim Storage facility;

f. Status of rod consolidation, dual-purpose casks, and other technological developments in spent fuel storage;

g. System optimization; and

h. The fee schedule established for the user-funded facility.

As these factors suggest, the Commission has explicitly recommended that the capacity limit and need for interim storage facilities should be reexamined in the year 2000.

QUESTION 11. Current law imposes several conditions on an MRS, such as State veto, congressional override, and impact compensation.

a. Should similar conditions apply to the facilities you propose?

b. How would you propose to avoid similar limitations?

RESPONSE:

Similar conditions should apply to the facilities proposed by the Commission.

QUESTION 12. On page 101 of your report, you state that "consistent with the NWPA provisions, an NRC license will not be required if the FES is located at an existing Federal site." What is the basis for that statement?

RESPONSE:

Taken in the context of the surrounding discussion, this statement was intended as the Commission's recommendation that an NRC license not be required for an FES located at an existing Federal site. The Nuclear Waste Policy Act of 1982 (NWPA) exempts from NRC licensing a Federal Interim Storage (FIS) facility located at an existing Federal site, but requires a finding from NRC that an FIS at a Federal site would adequately protect public health and safety. The FES recommended by the Commission is similar in size to the FIS authorized in the NWPA. Therefore, the Commission believes the same provisions with regard to licensing should be applied to the FES.

QUESTION 13. Could the FES and UFIS be used as staging facilities for shipments to the repository? If not, where would you propose to provide this capability?

RESPONSE:

While the Commission's studies did not demonstrate the need for a staging facility for shipments to the repository, studies now under way indicate there may be some advantages to tailoring the receipt of spent fuel to provide levelized energy deposition over the areal and temporal extent of the repository. However, spent fuel can be stored at the reactor sites and selectively shipped directly to the repository to provide the necessary mix of spent fuel.

With regard to the need for staging for transportation purposes, the Commission determined that the radiological and non-radiological transportation risks associated with both the No-MRS and MRS alternatives were small and are not discriminating in the determination of the need for an MRS.

Therefore, the Commission did not recommend the FES and the UFIS be used as staging facilities for shipments to the repository.

If there were a need for staging, there is no reason the UFIS could not be used for this purpose. It would not be expected that the FES would be used as a staging area since its primary mission is for emergencies. However, if the FES and UFIS were co-located, either one could serve as a staging area consistent with any capacity limitation, and consistent with the reservation of 1000 MTU of capacity for emergencies.

QUESTION 14. Your report recommends that the Federal Emergency Storage facility be located at an existing Federal site. What would be the recommended criteria for selecting that site and when would you expect the FES to be operational?

RESPONSE:

The Commission did not address the criteria for selecting sites for either of the facilities it recommended. According to the NWPA, as amended, the responsibility for site selection rests with the Department of Energy. The schedule for operation of the FES is addressed in response to Question 8.

QUESTION 15. The interim storage facility proposed by the Commission will seem to many people to be an unlinked mini-MRS. Mr. Radin, could you tell me how this recommended interim facility would be different?

RESPONSE:

The interim storage facility proposed by the Commission is different from the unlinked MRS in that it would be more limited in capacity (5,000 MTU versus 15,000 MTU); it would be user funded; and it would be an off-line facility--not all of the spent fuel in the nation's waste management system would pass through the facility.

QUESTION 16. What criteria would you recommend for selecting the location for the interim facility?

RESPONSE:

As indicated in response to Question 14, the Commission was not responsible for siting an interim storage facility and did not address siting criteria.

ATTACHMENT 2
December 20, 1989

LONG-TERM AGING OF SPENT FUEL

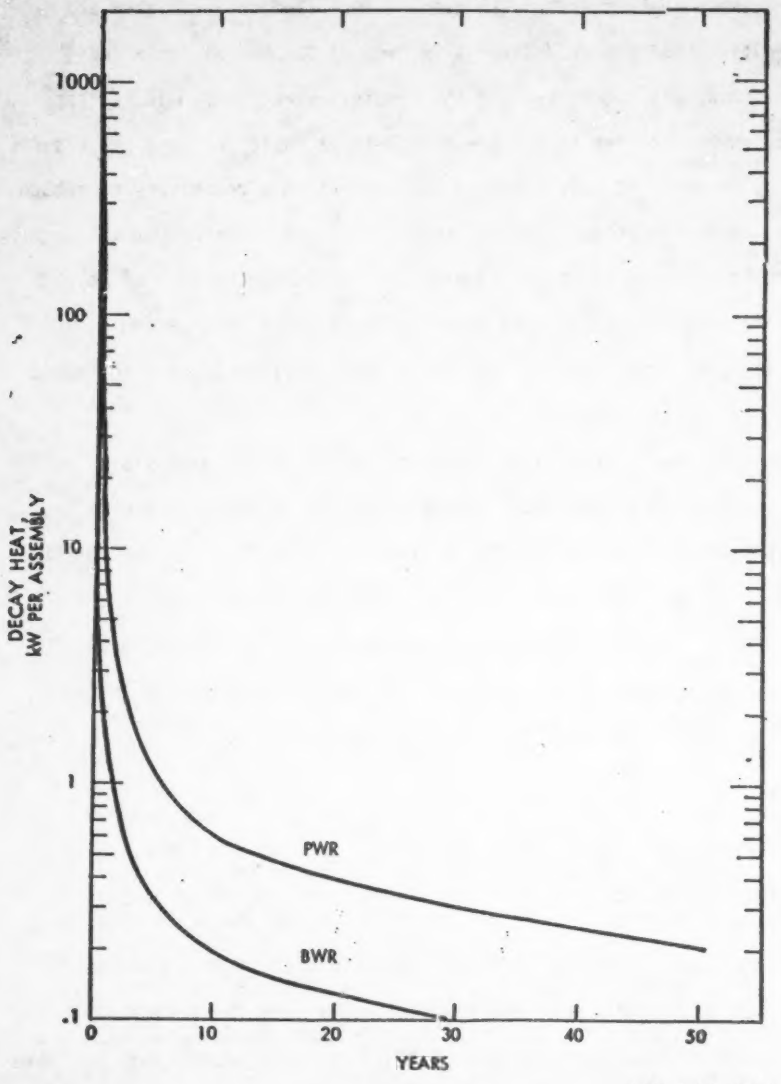
INTRODUCTION

At the November 2, 1989 hearings before the Senate Committee on Energy and Natural Resources on the final report of the Monitored Retrievable Storage Review Commission, Senator Johnston asked a number of questions concerning the need for long-term aging of spent fuel before it is emplaced in a geologic repository and the role of a monitored retrievable storage facility (MRS) if such aging is necessary or desirable. This report was written to address these questions.

Aging of spent fuel prior to emplacement in a repository is an important part of prudent spent fuel management. It allows time for decay of the shorter lived fission products in the fuel and reduces the thermal output (decay heat) of the fuel (see Figure 1). This could allow emplacement of more spent fuel per acre in a geologic repository, thus reducing the area to be excavated and the resulting repository costs, or it could reduce the technical uncertainties about thermal effect on the waste package and the emplacement medium if the same spent fuel spacing were maintained. The reduced thermal output would reduce the temperature of the host rock which would substantially reduce the scientific uncertainties in analysis of the interactions of the rock, ground water, backfill, overpack, canister material, and the waste.

As can be seen from Figure 1, the rate of decrease in decay heat decreases substantially after the first 10 years. However, the thermal output does continue to decrease. For example, for pressurized water reactor (PWR) fuel, the thermal output decreases from 1.1 kW/assembly at five years to 0.6

FIGURE 1 - Typical PWR and BWR Fuel Assemblies' Decay Heat Curves.



Hanford Engineering Development Laboratory "Spent Fuel Data for Waste Storage Programs" HEDL-TME— 79-20, September 1980, pg 45

kW/assembly at 10 years to 0.4 kW/assembly at 20 years to 0.2 kW/assembly at 50 years. The proportional decrease is the same for boiling water reactor (BWR) fuel. These numbers are for an average fuel element irradiated at nominal conditions (33,000 MWd/MT for a PWR and 27,000 MWd/MT for a BWR).[1]

As Senator Johnston observed and the Commission recognized in its report, other countries have chosen to age their high-level waste for long periods (in some cases up to 40 or 50 years) before emplacement in a repository to reduce the temperature in the repository host rock.[2] The reduction in thermal output of the waste is expected to result in peak host rock temperatures of about 100°C. The schedules of other countries for development of a geologic repository are protracted, in part because of the decision to cool the waste for long periods before disposal.

In contrast, the United States' program has placed its emphasis on moving as quickly as possible to develop a geologic repository and to begin to dispose of the waste. DOE has determined that geologic repositories for the disposal of spent fuel can be designed to dispose of 10 year old fuel safely in any of three media (i.e. tuff, salt, and basalt) and is designing its repository for acceptance of 10 year old fuel. The current DOE designs call for a peak temperature of about 200-250°C in the host rock.

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[1] In reality, spent fuel from a commercial nuclear power plant will have a spectrum of energy output at different ages depending on its initial enrichment, whether it was used in a BWR or PWR, and its burnup history in the reactor. For this general discussion, we shall use average conditions.

[2] Most European countries with nuclear power plants reprocess their spent fuel. (See Table D1--Summary Table: Spent Fuel and HLW Storage in Eight Countries in Appendix D of the Commission's report for a list of those countries that reprocess.) If the spent fuel is reprocessed, the resultant high-level waste is expected to be stored 20 to 50 years prior to disposal in a geologic repository.

Assuming a 2003 repository start-up date, DOE estimated that the average age of spent fuel received at the repository would be about 20 years.[3] If the repository start date were delayed until 2013 (which is reasonably close to the 2010 start date now being projected by DOE), the average age of the spent fuel would increase to about 30 years with the youngest fuel emplaced being about 20 years old. This aging of the fuel would occur regardless of whether there was an MRS in the system and the scenarios examined by the Commission encompassed this type of long-term storage. The question is whether aging of spent fuel for even longer periods would be beneficial and whether the benefits would outweigh the costs.

BENEFITS

Aging of spent fuel for additional periods of time (e.g. requiring that the youngest emplaced fuel be 30 years old prior to emplacement in a repository) could provide additional advantages in repository design (e.g. even more spent fuel could be emplaced in a given excavated area) or further reduce uncertainties about the potential adverse effects on the repository of thermal output from the spent fuel. However, an accurate determination of temperature decreases in the host rock associated with additional aging of the spent fuel cannot be ascertained without conducting a complex analysis for a given spent fuel package design emplaced in a particular array in a specific host rock at a specific site, and considering the relative merits of many available design tradeoffs. This is best done after a repository site has been characterized.

The thermal effects of spent fuel in a repository are complicated and

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[3] DOE Response to Questions from the Senate Committee on Energy and Natural Resources, July 16, 1987, Question 1d.

have a temporal as well as a spatial component. Repository design is dependent not only on the thermal output of the fuel at the time of emplacement but also on the integrated heat load over the life of the repository. In the short term, thermal output can affect the mechanical stability of the emplacement area both during the emplacement period and during the 50 year period following emplacement when it is necessary to maintain a capability to retrieve the fuel. In the long-term, the thermal output from the spent fuel can affect the integrity of the emplacement package (which by regulation must continue to function as a barrier to radionuclide release for at least 300 years), and the characteristics of the geologic/hydrologic environment (e.g. rock permeability, fluid flow, and chemical solute transport and reactions) which must be relied on to isolate the radionuclides in the spent fuel from the accessible environment for thousands of years.

The long-term thermal effects of spent fuel depend not only on the thermal output at the time of emplacement, but on the decrease of the thermal output over time. Both depend on the fuel's burnup history in the reactor, its age, and its original enrichment. In addition, thermal effects and their consequences will depend on the geologic/hydrologic setting (i.e. the emplacement medium, the moisture content of the emplacement medium, and the nature of the surrounding geology); the repository design (i.e. repository size and shape, emplacement depth, waste package spacing, and the total amount of fuel emplaced); the design of the emplacement canister (i.e. the size, shape, material of construction, and type of overpack); and the configuration of the spent fuel itself (i.e. consolidated or unconsolidated). When all of these factors are taken together, it is possible that for a specific site it

could be advantageous to maintain a higher temperature than at other sites. Preliminary studies have shown this may be the case at Yucca Mountain.

Figure 2 shows the temperature history of waste package components and host rock expected over the first 1000 years at the Yucca Mountain site based on preliminary DOE studies and assuming burial of 10 year old fuel.[4] As can be seen, the temperature of the host rock one meter from the bore hole in which the package has been emplaced will be above 100°C for the entire 1000 year period. There is an advantage to maintaining the temperature above 97°C (the vaporization temperature of the unconfined and unbound pore fluid in the host rock) to maintain a dehydration zone around the waste package. This decreases the possibility of package degradation and migration of the radionuclides in the spent fuel to the accessible environment. Therefore, extended cooling of the spent fuel may, in fact, be disadvantageous for the repository at Yucca Mountain.[5]

It also appears that, in terms of its effect on long-term far-field phenomena, long-term aging of spent fuel prior to emplacement may be of limited value. For example, thermomechanical and thermohydrologic

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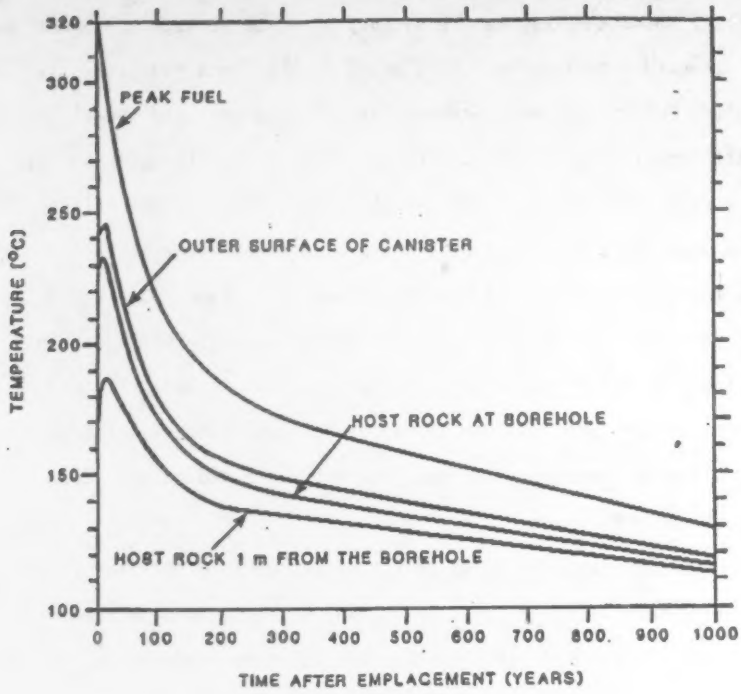
[4] Department of Energy, "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," December 1988, pg. 7-41.

[5] The potential benefit from maintaining a relatively high temperature in the vicinity of the canister only applies for unsaturated systems similar to those existing at Yucca Mountain. In a saturated system, water bound to minerals or trapped in small pockets or inclusions in the host rock can be released by heating and under some circumstances can migrate up the temperature gradient toward the waste package. This can result in a convective cell in which hot fluid is continually drawn into contact with the waste package and, depending on the chemical composition of the fluid, could result in corrosion of the waste canister. Therefore, if the repository were to be located at a site where the host rock were saturated, there could be additional incentive to reduce the heat output from the spent fuel prior to emplacement in the repository.

Figure 2 - Example Temperature Histories of Package Components and Host Rock for 10 Year Old Spent Fuel Emplaced in Tuff at the Yucca Mountain Site



INITIAL CONDITIONS

WASTE FORM	SPENT FUEL
LOCAL POWER DENSITY	57.0 kW/acre
AREAL POWER DENSITY	48.4
AVERAGE 10-YR POWER	3.3 kW
CONTAINER DIAMETER	0.7 m
DISTANCE BETWEEN CONTAINERS	5 m
DISTANCE BETWEEN DRIFTS	47 m

Source: W.C. O'Neal et al, "Preclosure Analysis of Conceptual Waste Package Designs for a Nuclear Waste Repository in Tuff", UCRL 53595., Nov. 1984, pg. 36

perturbations (e.g. surface uplift and subsidence) in the host rock formation depend on heat buildup in the entire formation over hundreds or thousands of years. These effects are dependent on the long-term integrated heat load from the spent fuel. However, the more important thermal effects are expected to be near-field effects which are quite sensitive to the thermal output of the fuel, and thus its age, at the time of emplacement. A 1983 study performed for the Nuclear Regulatory Commission by Lawrence Berkeley Laboratory[6] reached the following conclusions about the advantages and disadvantages of surface cooling:

"- Surface cooling allows more concentrated waste emplacement and lower thermal loading. The quantitative changes depend sensitively on the waste type and on the thermal criteria used in determining optimal loading.

- For the region in the vicinity of the waste package and the repository room-and-pillar, the lower thermal loadings associated with older wastes could reduce the short term temperature rise and the thermomechanical instability.

- Reductions in the near-field thermomechanical perturbations are significant for older wastes in salt and especially in hard rocks. If the near-field criteria determine the waste loadings, the creep analyses for salt and the thermoelastic analyses for hard rocks should be carefully evaluated to determine the optimal waste-loading densities for older wastes.

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[6] Lawrence Berkeley Laboratory "Thermal Impact of Waste Emplacement and Surface Cooling Associated with Geologic Disposal of Nuclear Waste," NUREG/CR-2910, March 1983, pg. 3.

- If far-field criteria are used, the extension of surface cooling periods will allow only a modest increase in waste density for spent fuel. The balance between a modest reduction in repository spatial requirements and the additional expense of the maintenance of surface storage facilities will be the determining factor in optimizing the duration of surface cooling."

COSTS

Aging of spent fuel, if desired, could be carried out at the reactor, at an MRS or UFIS, or at a surface facility located at the repository site. All are technically feasible, and the costs would differ with a number of factors such as the location of the storage, the size of the storage facility, and the status of the reactors at the sites, among others.

The Commission has not attempted to model the costs of extended aging, but the magnitude of some of the cost effects can be approximated by comparing the cost estimates prepared for the Commission's report. In Chapter Six of the report, the costs of delaying the repository until 2023 were estimated. As noted above, delaying the repository until 2023 would increase the average age of spent fuel received at the repository to 40 years and the age of the youngest fuel to about 30 years. For a system without an MRS, a delay in opening the repository from 2013 until 2023 would increase at-reactor storage costs by about $1.5 billion. At-reactor storage costs for a system with a linked MRS would increase by about $1.2 billion and the at-reactor costs for a system with an unlinked MRS would increase by about $0.3 billion for the same 2013 to 2023 delay.

If the unlinked MRS were used to age spent fuel, the reduction in at-reactor storage costs would be offset by the additional operating and capital

costs for the MRS. A ten-year extension of the period during which an unlinked MRS would operate before a repository opens would add about $150 million to total MRS capital costs (because larger facilities would be required to store additional spent fuel) and over $40 million per year in MRS operating costs. Ascertaining the actual increase in MRS costs or the cost savings to the repository which increased aging would permit is beyond the scope of the Commission's models and time does not permit us to modify the models to obtain accurate estimates of the total system life-cycle costs of increased aging.

CONCLUSIONS

After careful reassessment, the Commission sees no compelling reason to alter its original position on this issue by recommending extended spent fuel cooling periods, especially since, with the announced delay in repository opening and assuming oldest fuel first emplacement, almost all of the spent fuel will automatically be aged at least 20 years (see Figure 3).[7] However, since it is not possible at this time to allocate a meaningful dollar value to decreased scientific uncertainty resulting from emplacement of more aged fuel and we do not have the data available to calculate the savings in repository design and construction aging might permit or the overall costs to the waste management system of extended aging, we were not able to do the customary

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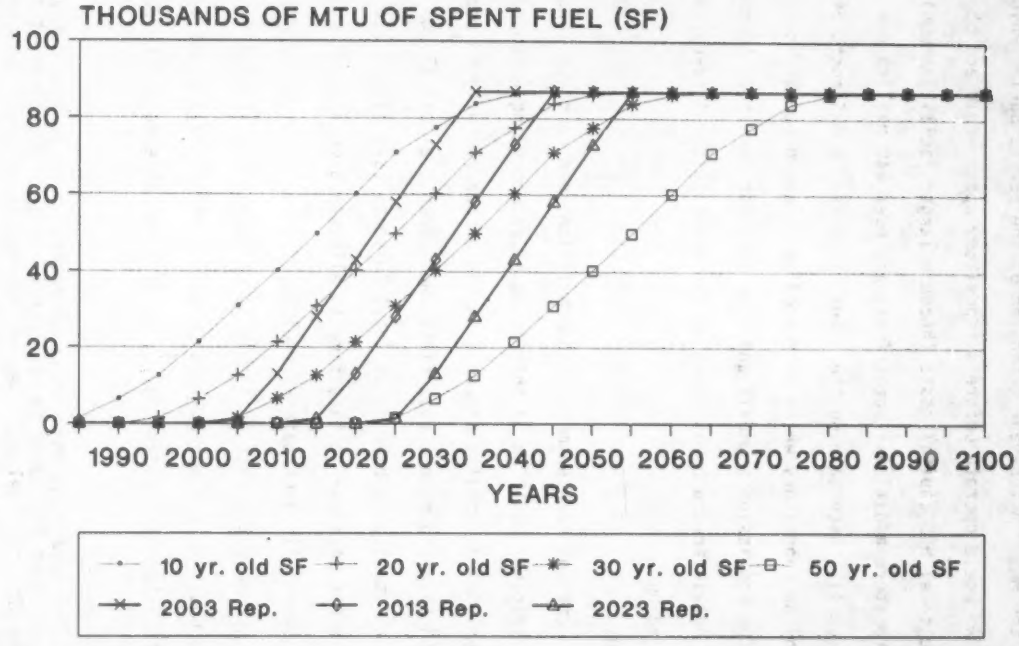
[7] If the repository were to begin operation in 2003 as DOE originally planned, and spent fuel were to be accepted at the repository at the rate proposed by DOE, the fuel emplaced in the repository would have an average age of about 20 years and the youngest fuel emplaced would be about 10 years old. If the repository were to begin operation in 2013 (which is close to the present DOE projected date of 2010), the average age of the emplaced fuel would be about 30 years with the youngest emplaced fuel being about 20 years old. If the repository opening were to be delayed until 2023, the average age of the emplaced fuel would be about 40 years and the youngest emplaced fuel would be about 30 years old.

FIGURE 3 - AGED SPENT FUEL AVAILABLE FOR SHIPMENT TO THE REPOSITORY*



* It is assumed that the repository accepts spent fuel at the rate proposed by DOE in appendix E of the MRS System Study Summary Report [Department of Energy, "MRS System Study Summary Report", DOE/RW-0235, June 1989], and is used to dispose of all 87,000 MTU of spent fuel generated by commercial nuclear power plants.

benefit-cost analysis for lower repository temperatures resulting from extended fuel aging. We note, however, that every other country designing geological repositories, all of which are in the saturated zone, has opted to limit peak rock temperatures to 100°C.

At this time a commitment to even longer spent fuel storage does not appear warranted. However, in the Congressional review in the year 2000, when more details about the repository and waste package may be available, the temperature rises in the repository host rock could be more accurately calculated and the issue could be reexamined with no loss in any of the advantages perceived at this time.